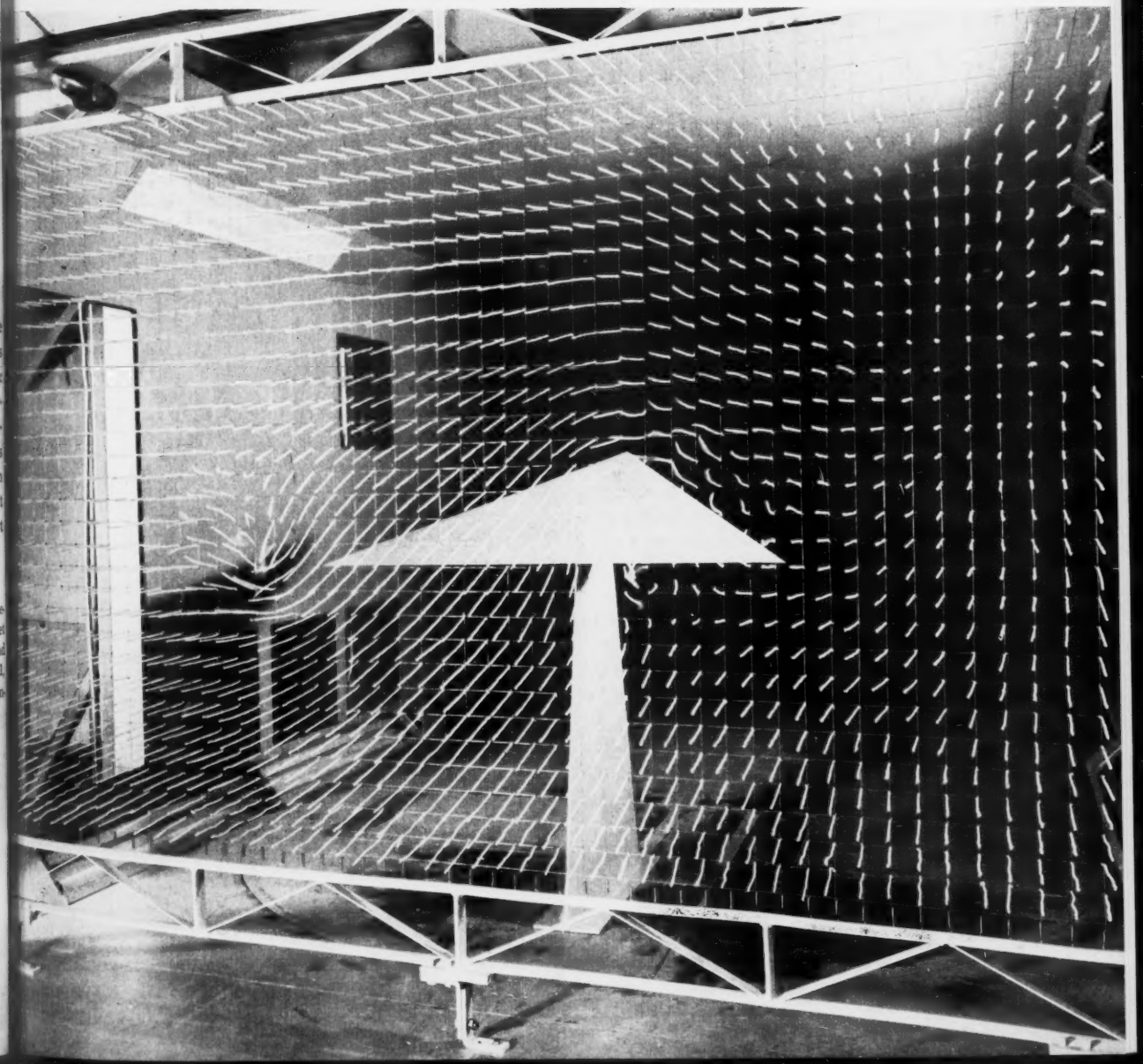
AERONAUTICAL ENGINEERING REVIEW

AUGUST 1951



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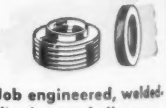

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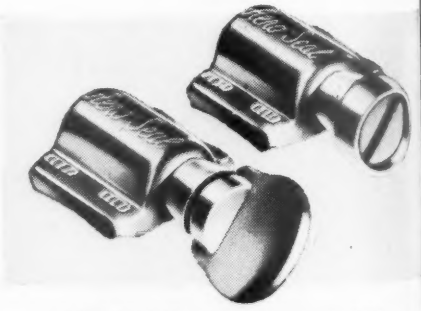

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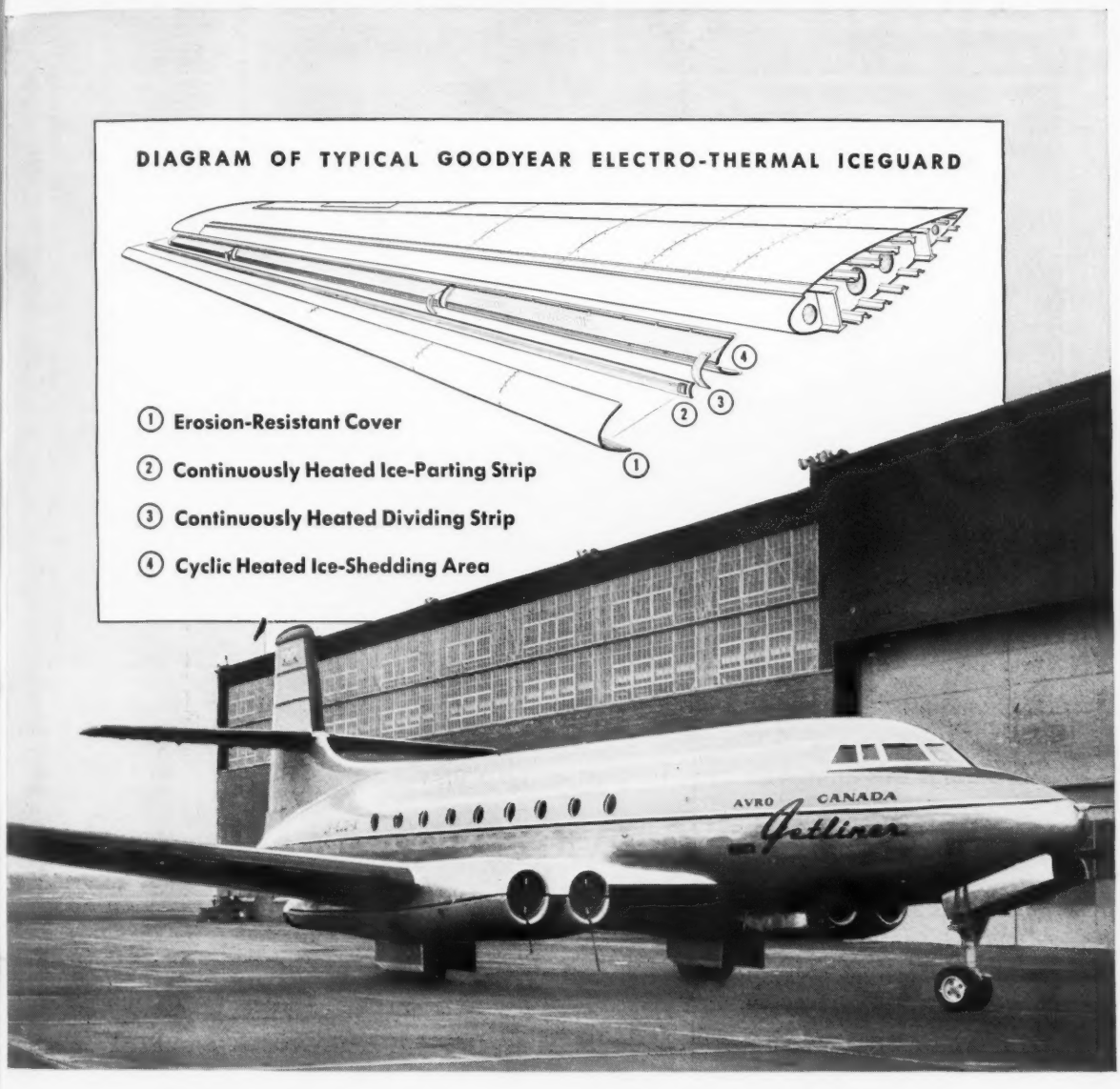

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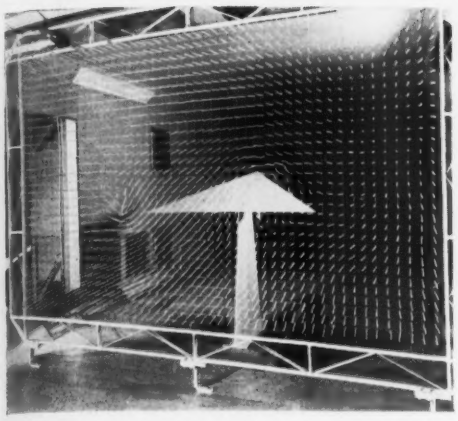

Cover—In the 7- by 10-ft. wind tunnel at N.A.C.A.'s Langley Aeronautical Laboratory, a wire grid with white wool tufts is placed in the wake of a delta-wing model, thus showing graphically the turbulence behind each wing tip.

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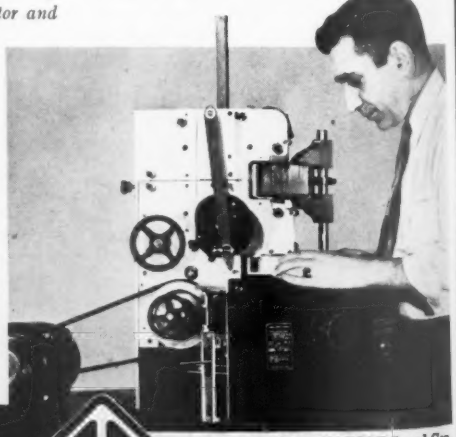

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I. A. S. News

A Record of People and Events of Interest to Institute Members

Bane and Chanute Awards Presented

J. B. Johnson and Lt. Col. M. E. Carl, U.S.M.C., Receive Bane and Chanute Awards at June 28 I.A.S. Dinner Ending Annual Summer Meeting in Los Angeles.

The Thurman H. Bane Award for 1951

John Burlin Johnson, Head, Metallurgy Group, Office of Air Research, Air Development Force, Air Research and Development Command, Wright-Patterson Air Force Base, Ohio, was the recipient of The Thurman H. Bane Award for 1951 "for his outstanding contribution in the field of high-temperature materials used in aircraft propulsion units." Mr. Johnson was associated with Air Materiel Command until the recent establishment of the two separate commands, A.M.C. and A.R.D.C.

▲ **Stainless Steel and Titanium Precursor**—Mr. Johnson, a pioneer in the application of stainless steel to aircraft construction, began work on the use of high-temperature alloys for aircraft power plants as early as 1930. He was one of the first persons to recognize the potential value to the U.S. Air Force of titanium and its alloys.

To permit a thorough investigation into the metallurgical structure and properties of ten of the most promising binary alloys of titanium, Mr. Johnson initiated work at five different research laboratories. During the past year or so, under his direction, the Metallurgy Group has established over 20 research projects at various universities, research institutes, and industrial laboratories. Among these projects are four investigations on titanium and its alloys through which further information relative to heat treatment and fabrication of these new materials may be obtained. Other intensive research is on the metal and metal-oxide combinations of silicon, molybdenum, chromium, zirconium, boron, and alumina.

The Thurman H. Bane Award, endowed by Major R. H. Fleet, honors the memory of Col. Thurman H. Bane, one of the most prominent technical officers of the U.S. Army Air Corps, who died in 1932.

John B. Johnson

The Octave Chanute Award for 1951

Lt. Col. Marion Eugene Carl, U.S.M.C., Head, Carrier Aircraft Section, Flight Test Division, Naval Air Test Center, Patuxent River, Md., was given The Octave Chanute Award for 1951 "for his outstanding contributions to evaluation of advanced-type Naval aircraft and for a continuously outstanding career devoted to the advancement of the art and science of flying."

▶ **Early Jet Test Pilot and Exponent**—Colonel Carl, a World War II ace with $18^1/_2$ Japanese planes to his credit, was assigned during the last year of the war to the Patuxent River Naval Air Station, where he was responsible for much of the early test work conducted on jet-propelled aircraft for the Navy during the formative period of this type of aircraft. This led to his becoming the first pilot to execute aircraft-carrier landings and take-offs in a jet-propelled airplane. Later, he flew a Douglas Skystreak to a world's speed record of 650.796 m.p.h.

During Colonel Carl's assignment from 1947 to 1949 as Commanding Officer of the Marine's first jet-fighter squadron, he led a jet stunt team that, in performing with notable success at Navy fields all over the country, may well be said to have had a significant effect in conditioning the Navy for the acceptance of this new weapon.

The Octave Chanute Award was established by the Institute in 1939 to honor the memory of Octave Chanute, pioneer American aeronautical investigator, who died in 1910.

Lt. Col. M. E. Carl, U.S.M.C.

Dinner Meeting: *This is the banquet that opened the First Annual West Coast Conference of I.A.S. Student Branches. The speakers' table is shown at the top of the columns of tables.*

West Coast I.A.S. Student Branches Hold Regional Meeting

The First Annual West Coast Conference of I.A.S. Student Branches was held on April 25–26 on the campus of the California State Polytechnic College, San Luis Obispo, with about 165 persons in attendance. Represented by these student members were the following schools: Northrop Aeronautical Institute, Cal-Aero Technical Institute, University of California, University of Southern California, and, of course, California State Polytechnic College.

▶ **Opening Dinner**—The official opening of the conference took place at the dinner meeting that was held at the Log Cabin Dining Room, 5 miles south of San Luis Obispo, at which Milo V. Price, Chairman of Cal Poly I.A.S. Student Branch, presided. The members were warmly welcomed by Lester W. Gustafson, Head, Aeronautical Department, Cal Poly; Julian A. McPhee, President of Cal Poly; and Ralph B. Priestly, Dean of Cal Poly's Industrial Division.

James V. Crawford, Administrative Engineer, AiResearch Manufacturing Company, a Division of The Garrett Corporation, was the guest speaker. His subject was "The Structure of an Engineering Department."

▶ **Technical Sessions**—Two technical sessions were scheduled for April 26 and were held in the Engineering Auditorium. Charles A. Johnson, Conference Chairman and Corresponding Secretary of Cal Poly's I.A.S. Student Branch, led the morning session; Clinton P. Sherburne, Vice-Chairman of Cal Poly's I.A.S. Student Branch, presided over the afternoon session.

The opening lecture at the morning session was given by Willis M. Hawkins, Division Engineer, Preliminary Design, Lockheed Aircraft Corporation, who spoke on "Trends in Military Aircraft Design." Mr. Hawkins was followed to the speaker's stand by three I.A.S. student-member speakers: Clinton P. Sherburne, Arthur L. Peregoy of Northrop Aeronautical, and Emory Eckert of Cal-Aero Tech. Mr. Sherburne spoke on "Are Jet Airliners Practical?"; Mr. Peregoy spoke on the "Development of a Small Open-Throat Wind Tunnel," and Mr. Eckert's subject was "Photo-Elasticity and Application to Aircraft." C. E. Knott, Assistant Dean of Cal Poly's Industrial Division, was the final speaker of the morning and explained the "Engineering Education at Cal Poly." A tour of the facilities at the College concluded the morning session.

The Log Cabin Dining Room was also the scene of the luncheon meeting on April 26 at which Milo Price again presided. The speaker on this occasion was Warren T. Dickinson, Executive Engineer, Douglas Aircraft Company, Inc., whose topic was "Trends in Commercial Aircraft Design."

Proceedings at the afternoon session were begun by another group of I.A.S. student-member speakers. The first was Charles M. Reid, Cal-Aero, who spoke on "Patch Stiffening of Thin Sheet Structures." He was followed by Kenneth E. Smith, University of California, whose topic was "The Hydrafoil Boat"; William E. Martin, Northrop, who talked on "Experiments in Gas Turbine Design"; and George F. Rugge, Jr., of Cal Poly, who chose the subject of "Electrical Resistance Strain Gauges." The student speakers were followed by Don L. Walter, Manager of Engineering and Manufacturing, Marquardt Aircraft Company, who addressed the assemblage on "Trends in Jet Propulsion." The final address of the session was presented by Prof. E. V. Laitone from the University of California who spoke on "The Study of Supersonic Shock Lines Using a Water Channel."

▶ **Awards**—Those talks that had been presented by I.A.S. Student Members were judged by the guest speakers—namely, Messrs. Crawford, Hawkins, Dickinson, and Walter—on the basis of the manner of individual presentation and the general interest of the subject. Toward the end of the afternoon session, the winners were announced by the panel of judges. Emory Eckert was judged to have won first prize. Kenneth E. Smith took second prize and William E. Martin was given third prize. These three winners were presented with appropriate awards by Milo Price. The meeting was then turned back to Clinton Sherburne, Chairman of the afternoon session, who formally closed the First Annual West Coast Conference of the I.A.S. Student Branches.

1951 Guggenheim Jet Propulsion Fellows Named

The appointment of seven new Daniel and Florence Guggenheim Jet Propulsion Fellows was announced recently by Harry F. Guggenheim, President of The Daniel and Florence Guggenheim Foundation; Dr. Harold W. Dodds, President of Princeton University; and Dr. Lee A. DuBridge, President of California Institute of Technology.

The selection of the Guggenheim Fellows is based on their technical ability, deep interest in rockets and jet propulsion, and demonstrated leadership qualities. They will carry out programs of advanced study and pioneering research at the Daniel and Florence Guggenheim Jet Propulsion Centers established late in 1948 by the Foundation at both Princeton and CalTech.

Four of the seven new Fellows have received grants for study at Princeton. These are Arnold Goldburg, aged 23, of Mahwah, N.J.; Marcus P. Knowlton, II, aged 22, an I.A.S. Student Member, of Auburndale, Mass.; Lt. D. M. Saunders, U.S.N., aged 30, of

Takoma Park, Md.; and Marcel Vinokur, aged 22, an I.A.S. Student Member, from Long Island City, N.Y. During the past academic year, Mr. Goldburg was a graduate student at Massachusetts Institute of Technology; Mr. Knowlton and Mr. Vinokur were seniors at Princeton and Cornell universities, respectively. Lieutenant Saunders was in his second year at the U.S. Naval Postgraduate School.

The other three appointees were awarded Fellowships for study at the CalTech Center. These include: George E. Hlavka, aged 29, of Racine, Wis.; Robert C. Evans, aged 23, an I.A.S. Student Member, from Pittsburgh, Pa.; and Herman Carl Thorman, aged 30, of Berea, Ohio. During the scholastic year just completed, Mr. Hlavka has been a Ph.D. candidate at CalTech; Mr. Evans was a student in jet propulsion at CalTech, and Mr. Thorman was a graduate student at Purdue University's School of Aeronautics.

The Guggenheim Fellowships carry a stipend of $2,000 annually and are normally awarded for one year. However, in certain instances they may be renewed for an additional year. All of last year's Princeton Fellows have had their grants renewed, including Major Dale D. Davis, U.S.A.F., of Effingham, Ill.; Clarence B. Cohen, T.M.I.A.S., of Mt. Vernon, N.Y.; John E. Scott, Jr., of Portsmouth, Va.; and David H. Ross, an I.A.S. Student Member, of Chicago. Those at CalTech whose grants have been renewed are: Thomas C. Adamson, Jr., an I.A.S. Student Member, of LaGrange, Ill.; Eldon L. Knuth, an I.A.S. Student Member, of Launa, Iowa; and Edward E. Zukoski, an I.A.S. Student Member, of Birmingham, Ala.

Special Libraries Association Meeting: *Pictured from left to right at the May 25 meeting of the Southern California Chapter of the Special Libraries Association meeting held at the I.A.S. building in Los Angeles are the following: Robert Vosper, Acting Librarian, University of California at Los Angeles; C. R. Graham, President, American Library Association and Librarian, Louisville (Ky.) Public Library; Mrs. Kathleen Edwards, President, S.L.A. Southern California Chapter; Dr. Luther Evans, Librarian of Congress; and Edwin T. Coman, Jr., Librarian, University of California at Riverside. Dr. Evans and Mr. Graham, who were the evening's guests of honor, spoke on the importance of maintaining close ties between the Special Libraries Association and American Library Association. Mr. Coman, principal speaker, discussed the plans under way for establishing and developing the new library for the University of California at Riverside.*

Space Medicine Society Formed

Paul A. Campbell, M.D., Colonel, U.S.A.F., A.F.I.A.S., Director of Research, Air Force School of Aviation Medicine, has been elected Chairman of the Space Medicine Society, organized last May during the Aero Medical Meeting in Denver. Dr. Hubertus Strughold, Professor of Aviation and Head of the Department of Space Medicine, was named Secretary. The Membership Committee Chairman is a Navy medical officer, Capt. Ashton Graybeil, Director of Research, Naval Aviation Medical School.

Space medicine is a relatively new science, having come into being within the last 10 years. Its development during that period has been commensurate with the improvement in the capabilities of jet planes and rocket-powered aircraft to reach the rarefied regions beyond the earth's atmosphere.

The Department of Space Medicine, headed by Dr. Strughold, was created 2 years ago by the present Surgeon General of the Air Force, Major Gen. Harry G. Armstrong, F.I.A.S., who at that time was Commandant of the School of Aviation Medicine. Its purpose is not only to keep abreast of questions evolving from the penetration of Homo sapiens into the farther reaches of space but also to anticipate these questions.

Under Colonel Campbell's direction, the Society will coordinate the School's inquiries with the studies of other investigators in this field.

Necrology

Charles P. Burgess

Charles Paine Burgess, I.A.S. Fellow and Founder Member, died in Washington, D.C., on March 19 after several months' illness.

Born in Boston, Mass., on April 9, 1888, Mr. Burgess was the scion of a noted family of naval architects. He studied naval architecture at the University of Glasgow in Scotland and was graduated from there in 1910.

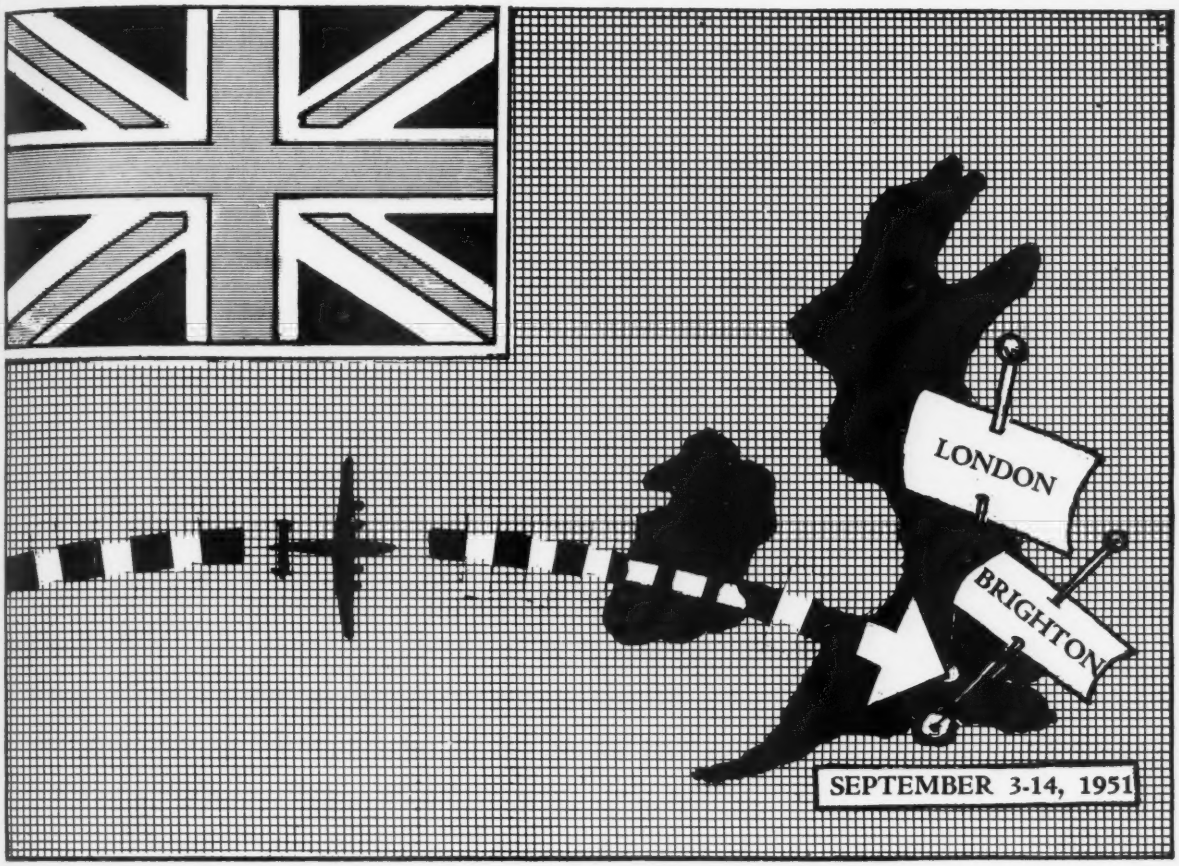
Mr. Burgess began his career in aeronautics upon entering Government service during World War I. From that time until his death, he was associated with the Airship Design Section of the U.S. Navy's Bureau of Aeronautics. When he first went into this work, the designing of airships was a new art in the United States with little scientific

(*Continued on page 42*)

Third

Once again the eyes of the Institute are turning eastward. Before the end of the current month, I.A.S. delegates and their families will be heading toward New York for the scheduled take-off for London on September 1. Some 75 delegates are making the trip, accompanied by more than 40 of their wives, children, friends, and relations. This sizable I.A.S. Expeditionary Force will stage a peaceful invasion of Britain from the Brighton Beach Head.

Since mid-May, the air mails and the cables have been busy carrying information back and forth—eastbound with the travel and accommodation requirements of our delegates and westbound with particulars of plans and programs designed to make our visits most pleasant and profitable. Everything possible is being done by Captain J. Laurence Pritchard and his able crew to meet the individual requests for travel and hotel accommodations outlined in each delegate's questionnaire. (Incidentally, as announced in an earlier issue of the REVIEW, Captain Pritchard retired on July 1 from his long-standing tour of duty as Secretary of The Royal Aeronautical Society. He has, however, agreed



International

to carry through the planning and programs for the Third International Meeting, after which he will begin to relax and enjoy his well-earned rest.) Those of us who participated in the first meeting in London in 1947 well remember the quality of British hospitality. We can guarantee a most agreeable time for all delegates during their sojourn in England.

But pleasant as we know these meetings will be, it is the profit motive that must predominate. We do not mean, of course, "profit" in the usual sense of the word. We doubt that any delegate from either side will return to his home base with personal wealth augmented by pound sterling—or by dollar standards. Each one of us, however, will leave the Conference far richer in those intangibles that really count—richer in appreciation of the other fellow's contribution to problems of common technical interest and richer in understanding of the other fellow's point of view as human beings of like mind with ourselves.

Facing a blank wall of deliberate misinterpretation of motives and deliberate misunderstanding of ideals to the eastward, it has become more important than ever that the two great English-speaking nations of the West stand solidly together on common ground. Historically, socially, politically, and technically we have a common heritage. Separated by 3,000 miles of ocean, we are sometimes inclined to forget it. Meetings such as these can do much to prove that the people of Iowa are really not much different in fundamentals from the people of Sussex. Engineering problems handled in Los Angeles are the same as those dealt with in Stag Lane or in Cricklewood. Every one of us should derive satisfaction and encouragement from the knowledge that we are not facing our problems alone—that we can sit down periodically with our colleagues overseas to exchange information and views with them which contribute immeasurably to the common good.

The response to the invitation to the Third International Conference on our side is most gratifying. We understand that it has been equally good in England. We all look forward to the establishment of another notable milestone to mark the amity that exists between our two societies and the countries to which they belong.

S. P. J.

Aircraft Adhesives, Sealers, and Coatings

I. G. CHRISTENSEN

Minnesota Mining & Manufacturing Company

ABSTRACT

There is a variety of methods for fastening together component parts in air-frame fabrication. Aircraft engineers choose a mechanical fastener, welding, brazing, soldering, or some other device on the basis of which is most advantageous. Judgment draws on established principles and familiar characteristics for the answer.

Adhesives may be overlooked in this process because they are not as well understood as other fastening methods. This is logical. Historically, the wood gliders of World War II appear to be the first units in which adhesives were employed as load-bearing factors by the industry. Progress has been made in adhesive compounding in the intervening years, usage has been extended, and there has been an opportunity to collect additional data on performance, durability, and application techniques. Outlining these can be an aid in revealing the utility of adhesives in airplane design and fabrication.

RUBBER-RESIN ADHESIVES

HOW MANY RIVETS are used to fasten to each other the skin sections of an airplane? How many holes are drilled and aligned for them? How many man-hours are spent bucking the rivets into place? *How much could be saved if the whole procedure could be replaced by something less involved?*

Aircraft engineers appreciate the conservation of time and material which would follow if, say, an adhesive took the place of mechanical fasteners in this operation. Air Force personnel and the aircraft and adhesives manufacturers have been working, and are continuing to work, toward the development of such an adhesive. Complex as the task may seem, there is a likelihood that it will be successfully completed.

That such an adhesive application is being seriously entertained denotes the progress of these sticky compounds since some were first used structurally in the fabrication of the wood gliders of World War II.

What about the less spectacular, present-day adhesive applications in air-frame design and fabrication? The aviation industry has undergone tremendous expansion within the past year. With it has come an influx of engineers, designers, and production men new to the industry. For them, and as a refresher course for the older hands, this section of this article points out the characteristics that make adhesives of most value in their work. At the same time, there is no implication that adhesives can replace other fasteners in all situations; therefore, some points are advanced toward establishing when adhesive use is an advantage. There are also some guides for picking one or two from the long lists of available adhesives which production testing should show as the best ones for any given job.

To keep the discussion within reasonable limits, the following adhesives are referred to: (a) those having rubber or rubber-resin solids; (b) solvent types or water dispersed; (c) air-dried, heat or solvent reactivated, or cured by heat or a chemical catalyst.

The authoritative selection of a specific adhesive for a particular job comes from an understanding of service demands, design and production factors, *and adhesive characteristics*. When these are clearly defined and related to each other, judgment will indicate whether an adhesive should be used at all, and clues will have been supplied as to what that adhesive should be.

The simplest answer would be an "all-purpose" adhesive. However, an airplane is an amazing thing, created from a complication of differing materials, each having its peculiarities when it comes to fastening it to something else. Therefore, it appears that an "all-purpose" adhesive is, to date, as remotely possible as the discovery of the philosopher's stone.

ADHESIVES VS. OTHER FASTENING DEVICES

A decision to use an adhesive rather than some other fastening means will be made when affirmative answers to one or more of these questions are in its favor. Will there be better performance? Longer life? Less subsequent maintenance? Decreased manufacturing cost? Accelerated production?

By their nature, rubber-resin adhesives have a number of characteristics that are hard to find in the same combination and degree in any other single fastening method. Listing these characteristics helps answer the above questions. So a start can be made here toward determining whether an adhesive is the best choice of all fastenings for any given job. The more important of these characteristics are:

(1) Adhesives distribute a load equally along a joint. Since there are no intermittent, local points of stress, fatigue of the joined parts is reduced. It may be possible to redesign for reduced weight or greater compactness.

Since most adhesives are strongest in shear and tensile, lapped or scarf joints are best. Butt joints are to be avoided (see Figs. 1–4).

Short radius bends along the edge of a bond should be used with caution. Another design factor to keep in mind is that there is an optimum depth of lap beyond which shear strength is not appreciably increased. Use of adhesives and structural materials beyond this optimum requirement entails cost and weight penalties.

(2) Smoother contours without gaps or voids can be achieved. It follows that an adhesive may also act as a sealer—a particle, vapor, liquid, or gas barricade.

(3) Adhesives may have electrical insulation properties that can aid in preventing galvanic corrosion of dissimilar metals. As a result of the same property, electrical units requiring grounding should be grounded to some component not insulated by an adhesive.

(4) For the most part, adhesives weigh less. Weight savings are always a concern of aircraft designers. There is a constant desire, for the same purpose, to specify thin gage metals and thin-sectioned materials. Other fasteners have a tendency to "pull through" these light-weight substances. Adhesives do not.

(5) Rubber-resin adhesives possess sufficient residual elasticity to absorb the stresses created by flexing in aircraft components and by differing coefficients of expansion. Compensation is made for vibration also.

(6) Generally, adhesives can be applied faster than most other fastening devices. On the other hand, an interval for adhesive drying or curing must occasionally be established in the production setup.

(7) Often the application of heat or the proper solvent permits the nondestructive separation of joined parts for repairs or replacements.

(8) Adhesives require little special surface preparation other than cleanliness. There is no need for punched or drilled holes and no aligning of such holes.

(9) Fastening together complex shapes or those with compound curves is not usually difficult when an adhesive is used.

(10) Adhesives can be corrosion-preventive coatings. Rubber-resin adhesives are moisture resistant, highly impermeable, and impervious to many corrosive agents, depending on the particular adhesive compound. They should, of course, be applied as continuous films between any two faying surfaces in order to act in both capacities.

To cite a specific example of how this last dual function might be utilized, consider the pressurized cabins of high-altitude aircraft. Some service conditions are described in a paper* by N. H. Simpson, Chief Chemist, Consolidated Vultee Aircraft Corporation:

"At the low temperatures encountered moisture from the breath condenses and freezes on the inside walls of the cabin. This water tends to accumulate by capillary action between lap joints and collect in low areas. As the carbon dioxide content of the air is above normal, the water has an acid reaction. This trapped water tends to break down insulation between dissimilar metals and promote corrosion through concentration cells, aeration cells, and general chemical reaction on similar metals."

It is in this general type of application that an adhesive can also be a corrosion-preventive coating, particularly in the lapped joints that Simpson singles out as highly susceptible areas. The adhesive will also exclude moisture from any area or material lying behind the bonded surfaces and which might also be subject to corrosion.

* Presented at the South Central Regional Meeting, National Association of Corrosion Engineers, October 3–4, 1949.

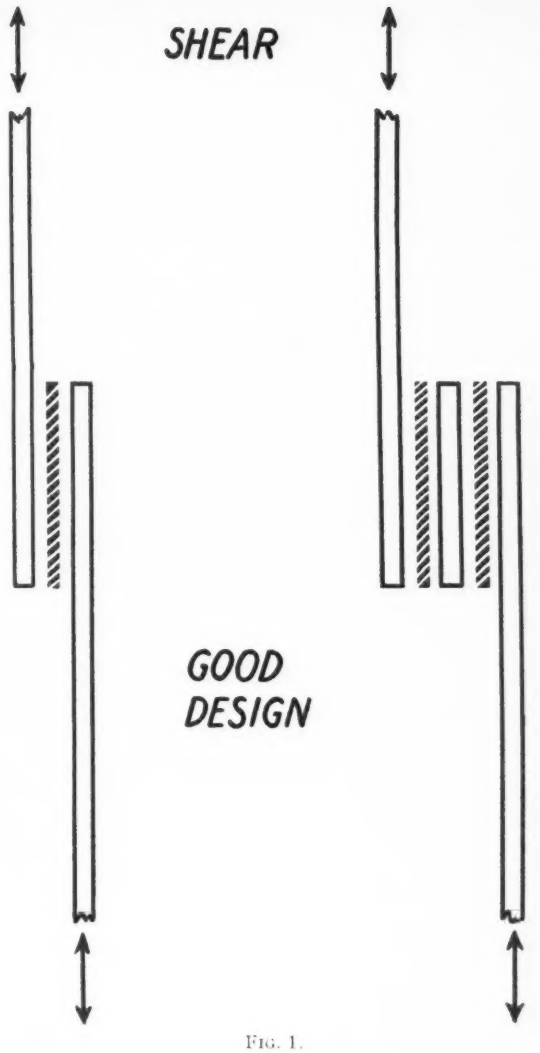


FIG. 1.

These are the principal inherent characteristics that help to determine the selection, over other methods, of an adhesive to do a fastening job. Then which adhesive shall it be?

Preliminary screening of adhesive possibilities can often be accomplished by studying the published product data. This will help to eliminate certain adhesive groups that cannot function under all these prevalent aircraft working conditions:

(*1*) *Temperature Extremes.*—The adhesive must continue to be effective in the heat of desert or tropic airfields, in the sub-zero temperatures met at high altitudes or on arctic airfields, and during rapid changes from one to the other.

(*2*) *Expansion and Contraction.*—As temperature changes, the adhesive must have sufficient adhesive and cohesive strengths and residual elasticity to withstand any stresses set up by the differing coefficients of expansion of the materials bonded.

(*3*) *Solvent Resistivity.*—Reciprocating engine and jet fuels, lubricating oil, grease, anti-icing and hydraulic

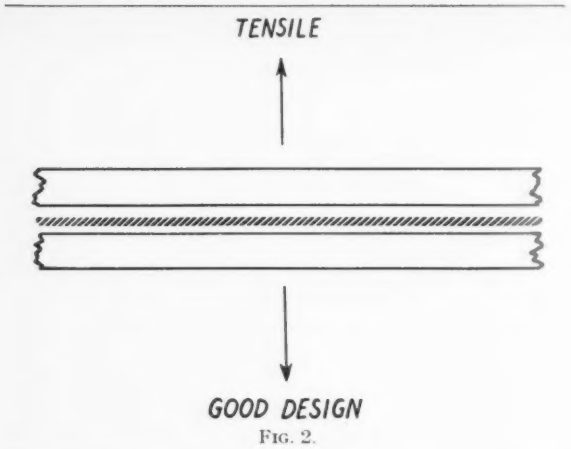
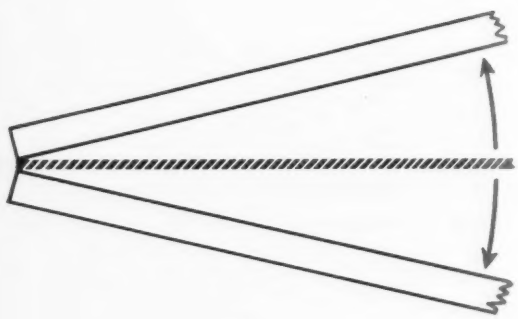


FIG. 2.

Shaded layers represent adhesive films

CLEAVAGE



FAIR DESIGN

FIG. 3.

system fluids are—often literally—a part of aircraft atmosphere. The chosen adhesive must be resistant to these and similar solvents. It is seldom necessary (except for such applications as the patching of self-sealing fuel cells) for the adhesive to resist immersion in such solvents, but it must successfully withstand occasional spillage or solvent fumes.

(4) *Mold and Fungi Inhibition.*—There must be an assurance that the selected adhesive will not support fungus growth. This is rarely a problem with rubber-resin adhesive.

(5) *Handling Characteristics.*—Also included in the product literature will be information on adhesive "open time," drying time, methods of application, and coverage.

"Open time" or working range is that period of time after adhesive application during which the faying surfaces should be joined to obtain satisfactory adhesion. Permeability of the materials to be joined, ability of the adhesive to wet material surfaces, solvent evaporation rate, ambient temperature, and relative humidity are the principal factors that determine open time for any given application. Open time is of most interest when a "wet bond" is to be made.

Adhesive drying time is the elapsed time until there is total dissipation of the solvent—the point at which all but heat-cured rubber-resin adhesives first achieve maximum strength.

There may be more than one satisfactory way to apply a particular adhesive. Standard application methods are by brush, spray gun, roll coater, knife coater, notched scraper, or spatula. These are for spreading adhesives over relatively large areas. For applying beads or fillets, a trigger-activated pressure oil-can, manually operated or air-driven flowgun, and ratchet type caulking gun are standard methods.

TYPES OF ADHESIVE BONDS

In a few cases the nature of the adhesive used may allow only one bonding procedure. Usually, however, several methods can be used; working conditions, service requirements, and the nature of the components being joined will indicate which method to adopt. How different types of bonds aid in achieving some common requirements is shown in Table 1.

These are the standard bonding methods for rubber-resin adhesives:

Wet Bond.—This consists of applying the adhesive to one or both faying surfaces and then making immediate contact or contact within the adhesive's open time.

Solvent Reactivated Bond.—The adhesive is usually applied to the more impervious surface and dried. Total solvent dissipation can be accelerated with controlled heat. The surface of the adhesive film is then reactivated by lightly wiping or brushing with a solvent. An advantage is that reactivation may be done after a considerable lapse of time. Upon reactivation, the surfaces are immediately joined.

Heat Reactivated Bond.—This is similar to solvent reactivation except that a heat-pressure stage replaces solvent wiping to make the adhesive film plastic and to restore its wetting ability. The same time lapse before reactivation is possible.

Chemically Cured Bond.—A two-part adhesive is used. One is a catalyst or "accelerator," which, when mixed with the other, initiates a cure of the mixture. The cure begins immediately; therefore, there is a time limit within which the material should be used. Since the cure is a chemical one, not involving evaporation or oxidation, the presence of air is not required during adhesive cure.

Heat-Cured Bond.—This can be an extension of any of the above methods when a "curing-type" adhesive is used. Applying heat to the bond causes molecular

TABLE 1
Types of Adhesive Bonds

Types of Bonds	Service Conditions To Be Met and Comparative Rating of Each Type of Bond: Fast, simple procedure required	Solvent vapors must be minimized	Solvent entrapment* will be a factor	Adhesive precoating desirable	Low initial shear or tensile required	High initial shear or tensile required	Increase in final strength desirable
Wet	A†	C	D	D	A	D	D
Solvent reactivated	B	B	B	A	D	B	D
Heat reactivated	B	A	A	A	D	A	D
Chemically cured	D	A	A	D	A	D	D
Heat cured	B	A	A	A	D	A	A

* Adhesive coated area is large; both faying surfaces are impervious.
† A = excellent, B = good, C = fair, and D = not recommended.

changes within the adhesive. These changes result in higher shear and tensile strengths than can otherwise be obtained. Some flexibility may be sacrificed in the process.

Laboratory and Production Testing

Whatever the application for which an adhesive is being chosen, preliminary laboratory and production testing will be required. The extent of this testing will depend upon how critical, new, and untried the application is. Understanding and utilizing the foregoing points will help establish the most revealing and conclusive test procedure.

The knowledge and research facilities of the adhesives manufacturers should also be employed in making adhesive choices. Aircraft engineers will know the performance requirements and service conditions of the components to be joined. Adhesives manufacturers will know *their* products equally well. Putting the two classes of specialized knowledge together will result in the best adhesive choice. Table 2 is included as a proposed outline of the facts that should be known and the questions that should be answered in making an adhesive choice. What materials are customarily joined by adhesives? What aircraft components are thus fastened together? A tabulation that does not include the facts sought by this type of check list would be inconclusive

In aircraft construction there is a particularly large requirement for rubber-to-metal bonding. For example, adhering a rubber gasket to a control junction compartment access door calls for an oil-resistant adhesive, since there will undoubtedly be free oil in the area. On the other hand, repairing a rubber deicer boot calls for a conductive adhesive to eliminate static electricity buildup. In each case it is a rubber-to-metal bond, but that is only a part of the story. Consequently, material or part lists seem inappropriate and are not attempted.

Sealers

The products discussed in the adhesives section were rubber-resin, solvent, or water-dispersed adhesives that air-dry or cure chemically. The permanently flexible sealers are limited in the same way, but with this additional qualification. Instead of being solvent or water-dispersed types only, these sealers may also be 100 per cent solids products.

Because the sealers used in aircraft fabrication are fewer in number and are used for specific purposes, it is practical and enlightening to take each of the major ones and present it in some detail. They are engineering accomplishments in themselves, capable of performing rather complex tasks.

Integral Wing-Tank Sealers

A sealer for integral wing tanks must make the tank compartments leakproof despite a harassing set of service requirements:

(1) Sealing is done in corners, where excessive shrinkage is hardest to control.

(2) The sealant must retain adhesion and resilience although the gasoline to be contained is an exceptionally good solvent and leaching agent.

(3) In lubricating oil compartments, the oil is intermittently subjected to heat and pressure.

(4) The wings in flight flex to a degree easily seen, and the sealant must flex with them without cracking.

(5) The sealant must remain firm yet flexible despite high or low temperatures and relatively rapid changes from one to the other.

(6) Should the tanks be purged in flight with some gas to prevent the formation of explosive fuel vapor-air

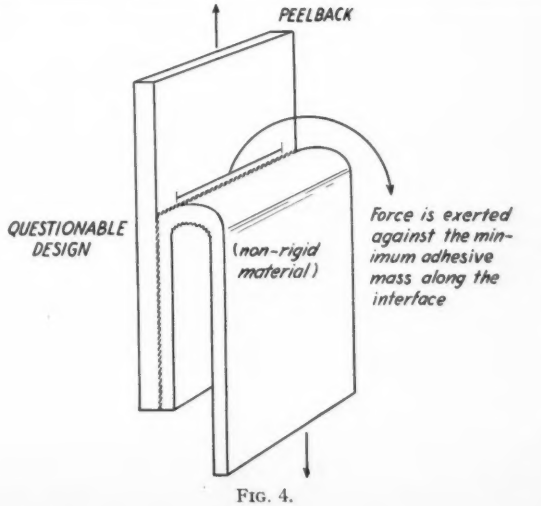

PEELBACK
QUESTIONABLE DESIGN
(non-rigid material)
Force is exerted against the minimum adhesive mass along the interface

FIG. 4.

mixtures, the sealant must be impervious to the gases employed.

Such a sealer is available and is familiar to aircraft engineers. It is a two-part, chemically vulcanizing synthetic rubber base sealer, the shrinkage of which is negligible. In its uncured state, it is a heavy liquid that cures to a tough, rubbery solid. A spatula knife or flowgun is used to apply fillets or spots inside the tanks. Fasteners or seams leading to a tank exterior are sealed and/or coated—unjacketed rivets, bolts, fittings, joints and points of attachment of spars, doublers, or stiffeners.

The sealer has outstanding thermal properties in the range of −100° to +210°F. Fuel immersion tests, using 40 per cent aromatic test fuel, result in low extraction and gum residue readings. This is an essential characteristic further improved when an easily applied barrier coating is used.

The sealer's tensile strength is in excess of 500 lbs. per sq.in., a property of increasing value as aircraft service ceilings are raised. Its adhesion to clad and unclad aluminum is excellent. It meets the requirements of Air Force Specification 14153 and Navy Aeronautic Specification S-151 as a tank sealant and of Navy BuAer Specification 52-S-10 as a pressurized cabin sealant. It will be found in many types of aircraft, including late DC-4's, DC-6's, and in many C-54-DC models.

This familiar black sealer now has a tan-colored counterpart with the same fundamental properties. Brushable variations in both colors have also been developed for speedier application than can be obtained by use of the "caulking gun viscosity" sealers mentioned above.

It may also be of interest to know that quick-repair variations (having faster curing accelerators) of all four of these sealants are available to cut overhaul and maintenance time to a minimum. They are effective under ideal conditions, but further work is being done on them to make them more tolerant and more easily assimilated into maintenance depot working conditions.

For wings so shallow that workmen cannot enter them, a fill-and-drain sealer has been developed—a one-part, synthetic rubber based, air-drying compound that develops high adhesion, excellent fuel resistance, and remarkable low-temperature flexibility. For unassembled wings of new aircraft, this sealer can be poured into the fuel tanks and then the wings can be rotated in a jig so that the sealer flows over all inside surfaces and members. Sealing the wing tanks of already-assembled planes can be done by fill-and-drain.

Pressure-Cabin Sealers

Prior to 1940, pressure-cabin sealing consisted primarily of applying ribbons of zinc chromate putty placed between faying surfaces of the materials that made up the boundaries of the area to be pressurized. The value of such a compound was limited by excessive cold flow during service.

Improvements came when a synthetic rubber based compound was developed which exhibited practically no cold flow and which was unaffected by the thermal shock encountered in flight. It was an oil-resistant sealer that developed high adhesion and had a high solids content with consequent low shrinkage. It was applied by hand flowgun or pressure extruding equipment, and variations were subsequently developed for application by putty knife, trowel, and brush.

The sealer was used in the cabins of several types of high-altitude bombers in World War II and continues to be used in long-range, high-altitude military aircraft, in the cockpits of jet-propelled planes, and in high-altitude passenger aircraft. Many of the newer airplanes with higher service ceilings, however, have cabins sealed with the previously described, heavy viscosity wing-tank sealer. Its performance at extremely low temperatures has been found to be superior.

In jet planes, sealers act not only to seal the cockpit to maintain air pressure but also to maintain the desired cockpit temperature. The cockpit of a jet streaking at 600 m.p.h. near sea level, it is said, could reach 200°F. if not effectively air-conditioned. An air-conditioning

Table 2
WHAT IS THE ADHESIVE EXPECTED TO DO?
UNDER WHAT CONDITIONS?
TO WHAT MATERIALS?

Whether the aircraft engineer is consulting with his company's adhesive expert or with an adhesive manufacturer, explicit and detailed answers to the following questions will aid in proper adhesive selection.

(1) What is the design problem? If possible, provide a working drawing or sketch indicating where the adhesive is to be applied. State the mechanical function of the bond, direction of stress, the product, or component end-use.

(2) What materials are to be bonded? If rubbers or plastics are involved, state the specific kind of rubber or plastic. Furnish clearly identified samples of adequate size where practical.

(3) What will be the physical condition of the materials at time of bonding? For example, if extruded or molded shapes, what kind and quantity (if any) of die lubricant or mold release material will remain on the pieces?

(4) If other types of fasteners have previously been used, what disadvantages were encountered? Uneven localized stress? Inadequate resistance to vibration? Inadequate sealing? Corrosion promotion? Too great bulk? Too much weight? Uneven contours?

(5) If an adhesive was previously used, what type? What were its strong and weak points?

(6) What will be the service requirements of the adhered unit? What is minimum bond strength needed? What temperature extremes will be met? Will there be exposure to weathering, high relative humidity, impact, abrasion, etc? If exposed to solvents or corrosive agents, will it be constant or intermittent exposure; to liquid or vaporous forms?

(7) Are adhesive color, odor, flammability, or toxicity important?

(8) What adhesive application method will be most convenient and practicable? Second best?

(9) Will any factors in preceding or succeeding production stages complicate adhesive usage?

(10) What approximate quantities of adhesive will be required or how many units will be produced in a given period of time?

unit becomes necessary to control cockpit temperatures within tolerable limits, but, to keep it effective, the cockpit must, of course, be sealed.

High-Temperature Sealers

Also specially compounded are heat-resistant sealants for sealing heater ducts and heat exchangers. This sealer is unaffected by continual operation in a 300°–350°F. range. It is highly resistant to deterioration caused by lubricating oil, hydraulic fluid, and 40 per cent aromatic gasoline. Common practice is to apply this product with a caulking gun.

Another sealer of the high-temperature-resistant type is that applied to aircraft fire-walls. This sealer, compounded to insulate and protect fuel tanks against flash fires in engine compartments, is designed to resist temperatures in the range of 2,000°F. for a minimum of 15 min. It will retain its adhesion and sealing properties at the specified temperature, for the specified time.

Fuel-Tank Access Door Sealer

The wing-tank sealers mentioned above have such high adhesion and tensile strength that they cannot be used to seal fuel-tank access doors. If they were, both the door and the wing structure around it would be warped or damaged in the process of removal. Therefore, another sealer has been developed with a controlled degree of adhesion which promotes easy, nondestructive removal of the access doors.

This sealer, applied by flowgun or putty knife, is a liquid that cures chemically to form a "gasket." Tough and rubbery in nature, it has excellent fuel, oil, water, and weather resistance. It is applied uncured to the periphery of the access door where it contacts its frame, and the door is immediately fastened in place in the usual manner. The "gasket" formed is tight and leakproof because the sealer flows around fasteners and fills all voids and gaps before curing.

Self-Sealing Fuel-Cell Sealer

Proved during the last war and still of paramount importance, this is a synthetic-resin-base compound chiefly used as an interior coating for the repair and reconditioning of self-sealing and collapsible fuel cells. It is also used to bond Buna N rubber patches in such cells and in other areas where water and aromatic fuel resistance is required. It may be brushed or sprayed. High resistance to cold flow, strength and adhesion through long service life, resistance to attack by immersion in aromatic fuels, and impermeability in the presence of fuel vapors are the sealer's principal characteristics. It is approved under Air Force Specification 26610.

Shock-Absorbing Sealer

To protect sensitive instruments and gages on aircraft control panels from mechanical shock, a thick-bodied sealer is available which literally provides a cushion against the jars of aircraft take-offs and landings, engine vibration, air turbulence, and, in the case of military craft, gunfire. It can be applied by flowgun or trowel as a cushioning sealer between instruments and panels. Thinned with water, it is also an adhesive for bonding vibration-damping materials to the instruments or panels.

General Purpose Sealer

Many miscellaneous aircraft sealing jobs require a nonhardening sealer for such operations as sealing fuselage windows and windshields in their respective airframe openings. A sealer with lasting resiliency is required here because of the differences in expansion and contraction of metal vs. glass or plastic. The available sealers for this type of application have excellent adhesion to metal, glass, and other impervious surfaces. Resistance to fuel, oil, water, and sunlight are inherent characteristics also.

Coatings

The following coatings are rubber or rubber-resin-based, solvent type, air-drying compounds. Good adhesion to impervious surfaces and lasting resiliency are general characteristics; individual characteristics vary as the products and their principal uses vary.

Aerodynamic Smoothers

The ideal airplane is said to be one which is aerodynamically smooth over all exterior fuselage, wing, and tail surfaces—particularly leading edges—so that air turbulence in the region of rivets and lapped joints does not occur.

Increased skill in designing and assembling air frames moves the aviation industry constantly closer to this goal of absolute airfoil smoothness. However, there are construction limitations in some types of planes which make it necessary to use an aerodynamic smoothing compound over discontinuous skin areas and mechanical fasteners to give those planes smoother lines than can presently be obtained by assembly methods alone.

Two types of smoothers are in use at the present time. One is a 100 per cent solids, two-part, aluminum-colored, synthetic rubber compound that has exceedingly wide thermal limits. The other is a one-part compound with somewhat narrower thermal limits. Both have high adhesion and are unaffected by fuel, oil, sunlight, or water. They are applied by trowel or flowgun. Both are capable of being sanded and feather-edged by standard sanding procedure to fade imperceptibly into adjacent contours.

Erosion-Resistant Coatings

Another problem of high-speed flight is the erosion caused by the impact of dust, rain, and other precipitation products on wing, tail, and stabilizer leading edges and other vulnerable parts. It is a problem that is being approached in a number of different ways, but

rubber-resin coatings appear to have certain advantages because of inherent characteristics.

These qualities roughly in order of importance are: (1) adequate adhesion to aluminum, magnesium, and plastic laminates; (2) extensibility—the ability to flow around impinging particles to dissipate the energy of impact and then rebound to original contour; (3) air-drying characteristics; and (4) speedy application by spray gun.

To these general advantages is added one further, important quality—that of aging and weathering to a tougher, more durable film. Tough, resilient films with good adhesion appear to have a better opportunity to succeed as erosion-resistant coatings than do hard-finish materials.

Radomes are especially subject to erosive action. Their protection is also complicated by the fact that any coating applied must not interfere with radar signals. Protection without interference appears possible through the application of a synthetic-rubber-based coating system consisting of a primer, tie-coat, and top-coat. This system has been flight tested on one type of military jet aircraft for six months at the time of writing. Flights have been made at high speeds through rains without any discernible injury to the coating system, although some flights were under conditions severe enough to shatter plastic camera port covers.

The wing and empennage leading edges on the same jet plane are protected by a two-coat rubber-resin system. In the same service tests, it proved effective and is, obviously, more easily and quickly applied than the three-coat system. It consists of a black synthetic-resin-base top-coat for abrasion resistance cushioned underneath by a gray synthetic-rubber-base coat for impact resistance.

The two-coat system has been approved for use on two types of military aircraft and is being examined for additional approvals. Because of its more critical location and the increased demands made of it, the three-coat, radome coating has not yet received official sanction. However, the company that designed and built the jet airplane to which it was applied is confident that coating function will meet requirements.

Looking to further simplification, it is noteworthy that encouraging results are also being obtained from tests conducted on a one-coat erosion-resistant coating for wing and empennage leading edges. This, too, is a rubber-resin coating. Like the two-coat system, it has been tentatively approved for two types of military aircraft, and there exists within the industry an apparent preference for utilization of the one-coat system.

Strippable Coatings

Of particular interest to the industry is a recently perfected strippable coating for temporary protection of air-frame subassemblies during manufacture, storage, transportation, and final assembly. This sprayable coating air-dries to a thin, but exceedingly tough, mar-resistant film that is particularly valuable in protecting fuselage, wing, and tail subassemblies from mechanical abuse. At the same time its adhesive strength, less than its cohesive strength, is adjusted so that at the proper time the protective film can be easily hand-stripped or blown off with an air blast.

Antiglare Coatings

What would appear to be a relatively uncomplicated problem is that of protecting the pilot's eyes from sunglare off the fuselage directly below the windshield. A flat black coating is often applied in this area. However, such films in flight are subjected to the craft's high speed and violent slipstream and too rapidly changing temperature extremes. All but specially compounded coatings may become embrittled and flake off as a result.

To meet this need, a two-coat system has been devised—a primer and a top-coat, both having synthetic-resin bases. The primer affords the tight adhesion to metal necessary for such an application, and the top-coat (a flat black) eliminates the glare. The coatings are applied by standard spray methods and have wide temperature limits and a permanent resiliency that enables them to resist flaking.

Nonskid Coatings

Servicing and maintaining aircraft often require walking on slippery wing-walk areas and in cargo compartments. To provide safe footing, another synthetic resin base, two-coat system has been developed. It consists of a primer for good metal adhesion and a top-coat in which a grit is suspended. The grit is a non-mineral, nonsparking type, essential when fuel is being loaded. It is made by one manufacturer in gray, black, maroon, and aluminum.

I.A.S. Twentieth Annual Meeting

Authors wishing to have papers considered for presentation at this meeting should submit outlines or short abstracts to the Meetings Committee, 2 East 64th St., New York 21, N.Y., no later than September 15, 1951.

Future Air Transport Possibilities*

GROVER LOENING

"VENTURING INTO FUTURE PREDICTIONS is a tricky business and one which should be entered into with considerable reserve.

"A useful service could be served, however, in venturing into the as-yet-unknown if it is not done too often—if it is done with reasonable logic—and if at least it were to inspire argument, thought, and ambitious enterprise. The first thing we must do properly to appraise the future of air transport is to look straight in the face, and with a rather brutal realism, at our faults and shortcomings and 'phony' trends, while at the same time we pick out the clear lessons of our past performances and give proper weight to those factors that our history has clearly shown to be correct. To give good judgment on what is to come, let us look at some of the paths we have traveled.

"Thirty years ago air transport of mail had begun in this country. In Europe, development of passenger air lines was initially much more rapid than here, particularly in Germany and England. In fact, let us not forget that up to 1928 Europe was conspicuously ahead of us in passenger air lines, and it was not until then that we began to forge ahead, largely because of the stimulation of Lindbergh's historic flight accompanied by the prosperity boom of 1928 and 1929. Our first serious mail plane (Fig. 1) was the modified DH-4 used by the U.S. Air Mail Service, which had gross weight, 3,740 lbs., useful load, 850 lbs., cruising speed, 90 to 100 m.p.h. In 1926 the Government operation of the postal air-mail service was turned over to private contractors, and one of the first planes specifically designed for this service (and a successful one) was the Boeing type 40. This had a gross weight of 5,600 lbs., a useful load of 1,600 lbs. plus room for two passengers in a small cabin, and a cruising speed of 115 to 120 m.p.h. I made a transcontinental trip in this plane around 1927, and I recall that it took 32 hours. We made 14 stops, and the cost was $400 one way.

"Of considerable interest at that time, and apt to be forgotten now, was the Curtiss Condor, which was a fine, large, 18-seat passenger plane. The gross weight was 17,400 lbs.; the pay load was 3,600 lbs.; the cruising speed was 118 m.p.h. This plane was in the service of Eastern Air Lines in its earliest days and also Transcontinental Air Transport, which later grew into TWA.

"Note that these early planes were still biplanes. The introduction of the monoplane into air usage in America was an extremely difficult process. The prejudices against it were perfectly silly, but they were powerful. It was supposed to be inherently weaker, less stable, a death trap on fast landing, and more difficult to keep in alignment and was generally considered the type of aircraft which belonged in the racing category and not in the serious load-lifting class. It is incredible today, when we have the universal adoption of the monoplane as the correct type of aircraft, to look back upon those days and actually see the great delay and cost to the industry that these childish and partisan prejudices introduced into our progress or, rather, lack of progress. Also, it will be noted that these early planes did not have retractable landing gears. That, of course, was because the complication would be too dangerous; if the mechanism did not work, then what would you do? Also, they did not have variable pitch propellers, although such were available, because that would add to weight and complication and danger for a useless purpose. I could devote the rest of the paper to reviewing the perfectly ridiculous decisions and prejudices that guided aircraft development in those early days, such as the famous Government specification prohibit-

FIG. 1.

FIG. 2.

* Lecture delivered before the New York Section, Institute of the Aeronautical Sciences, May 3, 1951.

ing the use of aluminum in any structural part of an aircraft. The only merit in mentioning them is to be sure that we are not doing the same sort of thing today. As a matter of fact, we are. It is merely human nature.

"Around this time also, of course, was the ubiquitous Ford trimotor. Henry Ford, in the middle twenties, undertook under his own cognizance to create and operate an air line, at first between the far-flung Ford enterprise factories. Bill Stout designed the plane, and the Ford trimotor became one of the most widely used and successful airplanes in the history of air transport. It was a 12-passenger plane with a gross weight of 10,130 lbs., a useful load of 3,600 lbs., and a cruising speed of about 108 m.p.h. The Ford trimotor is still in operation in some parts of the world. It is interesting to note that this excellent craft has survived a useful life of over 25 years.

"The Boeing 247-D is also an important milestone in our air transport progress (Fig. 2). It was a highly successful plane and was the first one that really introduced the present type of aircraft configuration. The gross weight was 13,100 lbs., the useful load was 4,700 lbs., and the cruising speed was 171 m.p.h. The 247-D was soon rivaled by the Douglas DC-3, and from here on in our progress we have the familiar planes of today—the DC-3, the DC-4, the DC-6, the Convair 240, the Lockheed Lodestar, the Lockheed Constellation, etc. In this brief review, I will concentrate on the domestic air-line picture in the United States and will not venture into the additional field of international air-line development or of European types of development.

"Since the present-day types are so familiar, there is no necessity to go into the details that relate to them, and we can at once take a look into the new planes that are about to enter air-line usage.

"The new long fuselage Super-Constellation is a fine looking logical development of this great plane. It will carry many more passengers, will cruise 30 or 40 miles faster, and should be a considerable improvement all around on the present Constellations.

"The Boeing Stratocruiser is, of course, not really a new plane, since it is already in wide usage. However, it represents the first two-deck variety in air transport, and its high performance entitles it to special consideration.

"The Convair 340 is the longer, larger, faster version of the immensely successful 240, which to date has an unusual record of reliability, safety, and service for an airplane in wide usage.

"The Douglas DC6-B is the faster, longer, slightly larger version of the famous DC-6 and is going into wide usage most successfully.

"Except for the turboprop version of the Convair now undergoing most promising test flights, we must look other than at America for the presently revealed coming progress. First, we have in England the 'Brabizon' huge 300,000-lb. air liner with 8 engines or various combinations of jets and engines as yet undetermined. But note in the progress of this one that it is not particularly fast, and we can venture to predict that its

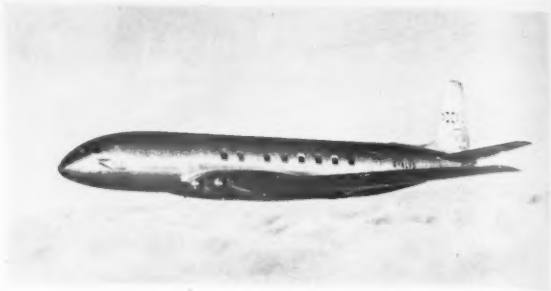


FIG. 3.

FIG. 4.

size is not going to be an advantage in air-line operation. Size is essentially useful in a slow aircraft. If we can get our trips down, even transatlantic ones, to 5 or 6 hours, size will have no virtue compared to additional frequency of service which smaller sized planes could give.

"The de Havilland 'Comet' is, of course, familiar to all of you and is the first jet transport actually going into service (Fig. 3). It cruises at 500 m.p.h. and has everybody arguing about whether it is the right thing or not. But we will see the results of this within the next year or two, and the prediction is ventured that it will start, without any question, the obsolescence of piston-type aircraft.

"On this side of the Atlantic we have the conspicuous Canadian achievement (which has many of us still rubbing our eyes) of the highly promising Avro 'Jet Liner' (Fig. 4). The technical press has amply covered the performance and characteristics of this aircraft, but it also approaches, and is a notable step toward, the 500-m.p.h. class.

"These, then, are a few highlights to give us background.

"As things stand today, air transport may, in general, be accused of having the following shortcomings:

"(1) Fast as it is in long haul, it is not fast enough on short hauls of a few hundred miles to be really effective between home or office and actual destination.

"(2) It is not reliable enough from an 'on-time' standpoint to be counted on in the opinion of too many people.

"(3) The safety and comfort of air travel, great as they now are, are still not up to the standard of complete acceptance.

"(4) The great importance to our Government and to our people of air transport development as a background for national defense strength in case of war is still not yet realized or appreciated.

"But we can be of stout heart because every one of these points is either presently being met or will be met and conquered by technological developments that are only too clearly in process of successful attainment.

"Let us take *speed*. The history of air transport development started in 1920 with a speed of 90 m.p.h.; it went into 1940 with a speed of 180 m.p.h. and then started a real zoom to well over 300 m.p.h. in 1950, and, projecting the curve, to an easy 500 m.p.h. by 1960 (Fig. 5). Allowing then for the transition from the transonic speed range and taking the same rate of speed increase thereafter, a speed of 1,000 m.p.h. by 1970 and 1,200 m.p.h. by 1980 is what the chart would indicate.

"This has to do with the speed of cruising. The speed increase from destination to destination has not increased at the same breathless pace. The chief reason for this is that in our design progress we have also increased landing speeds, which has meant the requirement of larger airports, which in general have to be farther out of town and away from the destination of home or office. This is really the one factor that has caused short-haul air transport to be so limited up to date. However, are we not in the process of overcoming this?

"The now wide enthusiasm about helicopters is merely an expression of the subconscious feeling that we all have that travel through the air in whatever vehicles we devise is not a complete mode of travel until we arrive at vertical flight, as well as fast horizontal flight. The helicopter gives us vertical flight but at the moment is limited in practical utility by its slow speed of cruising. The realization that this needs further development is evidenced by the increasing activity of designers in venturing into the area of so-called 'convertiplanes,' in which a rotor system does the vertical flying work of take-off and landing, and a transformation is then made into a fixed-wing airplane of high cruising speed. Further areas of development exist, one of the most promising of which is the development of induced airflow over the wings for the slow-speed régime in jet-engine configurations. This slow-speed airflow, to give lift for taking off and landing, is ducted, by-passed, or otherwise modified into a straight propulsion thrust for high-speed, fixed-wing operation.

"Just as surely as we will be able to cruise at 500 m.p.h. by 1960 on jet-engined transports, one can venture to predict now that the importance of slow landing and what it will mean in the way of improved air transport operation will be realized shortly. This will lead to a lower landing-speed era, perhaps almost a craze, which should come to fruition in the next 10 years and which will mark a tremendous step in the practical development and enlargement of universal air transport. Thus, we will end up by not only giving the passenger 500 m.p.h. while he is in the air, but also actually transporting him from his starting point to his destination without such a proportionately large amount of time wasted in taxicabs and buses to get to the outlying areas that large landing facilities demand.

"There is an additional item of great importance to consider with regard to the speed of air travel. To begin with, history shows us clearly that a slower aircraft for almost any purpose, civil or military, never goes into great usage (exactly as slow cruising speed is now limiting the helicopter). In air transport, cruising speed does not cost anything extra with regard to the wages and salaries of the crews operating the aircraft. Therefore, as soon as we pack more passenger miles, by virtue of a higher speed, into the hours of the crew and maintenance workers' duties, we greatly increase income without increasing expense in anything like the same proportion.

"As an illustration, let me cite the following: In general, in present air transport operation, 44 per cent of the air lines' expense is in wages, and 13 per cent is in fuel. This is based on the present more or less 300-m.p.h. cruising speed of our present planes. Let us assume that we go, for example, to a jet plane using twice as much fuel but traveling twice as fast. Since fuel at present is only about 13 per cent of total operating costs, we have the following comparison: Wages plus fuel in our present régime is 44 plus 13 or 57 per cent of total cost. If, now, we double the fuel, it is 26 per cent of the total cost. But if we double the flying speed, we double the passenger-mile income per hour, and, in doing so, our wages would then become only 22 per cent of that income dollar. This, plus the 26 per cent fuel charge, would make the new 600-m.p.h. cost of wages and fuel only 48 per cent of the total. In other words, by no change at all, other than to fly the faster airplane, even though it does use twice the per cent of fuel per mile, the air line makes 10 per cent more profit.

"Regardless of other considerations or whether or not the traffic and financial condition of the companies has progressed in the last year or two, I venture to point out to you that the real reason the air lines have made more money in the last few years is because the speed of most transports has increased enormously—in some instances well over 50 per cent.

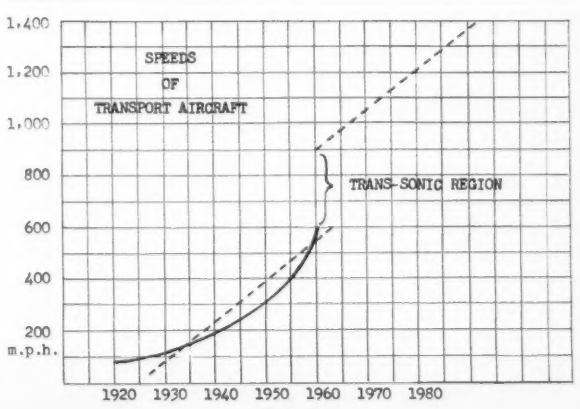


FIG. 5.

"Now to go to our second point about how reliable we are, let us look at this one: The teasing adage, 'If you have time to spare, go by air,' is not to be dismissed too lightly if we want to build up our business on a sound basis. I do not have the figures for this year, but some two or three years ago, at the time of the President's Air Policy Commission's studies, an investigation was made of air-line regularity, and I would rather not give the figures because it is not good advertising for the air lines. As a frequent user of air lines, however, I can testify that today conditions are greatly improved. One can make appointments in the future now with considerable confidence involving air travel. But the fact is that there are still too many delays. The delays due to operation activities, such as baggage loading, equipment failure, people losing their tickets, planes held for late passengers, etc., are still too frequent but are becoming notably less so. There is still the delay due to weather, not only to the flight that one is engaged in at the moment, but due to shortage of equipment that could not arrive for turn-around because of delay in some other region.

"This is definitely in process of solution, as we all know. Navigation aids, weather reporting aids, blind flying aids, and increasing improvement in solving the stacking up over busy airports are all being devised. What is important to realize is that they are all capable of solution, so that it would be extremely short-sighted to take weather delays as a fundamental reason for a limitation in air transport development. Some of us can go way back to the 1910 era, when a wind of over 30 m.p.h. stopped all flying for the day without any further question. And to those of us who have witnessed the growth of the power with which a modern aircraft masters weather, confidence in the solution of these troubles is convincing. Flying blind is likely to be solved in the cockpits rather than by the interesting and ingenious outside aids that are under such excellent development at present. A combination of radar and television should be forthcoming presently that will put a screen in the pilot's cockpit, giving him as good a view of what he is flying near or over as he gets on a clear day. When this takes place, there is no further need for the elaborate stacking up and instrument procedures, unless the pilot's blind flying screen goes out of commission. In addition, reliability in getting a passenger from his take-off from home or office to his actual destination will be further enhanced when we deposit him much nearer these destinations by vertical landing aircraft.

"The third point made is that of safety and comfort. Safety is a large subject for a short presentation like this one to cover adequately. But there are a few points that need emphasis and encouragement. More can be and should be done at once on fire-proofing aircraft or on dispositions that will prevent fires after crashes. This is not difficult to solve. Fireproof construction of passenger compartments to resist for some time the fire of the fuel in the wings is by no means a design impossibility. In the heavy competition that we have in this country to improve new designs so that they can be sold, this will be high on the list, and, therefore, it will be done. Safety of the passengers in the crash—at least reduction in the injuries that they can receive—is certainly clearly capable of improvement by some simple measures, as evidenced by the excellent work of the Flight Safety Foundation, the Guggenheim School at Cornell, etc. Recently, for example, has come the suggestion that seats be tiltable by being mounted on a roller frame so that in an impending crash the passenger would literally lie on his back on the floor with his seat in a vertical position, greatly protected from being thrown or injured. Therefore, to cast a limitation upon air transport's development on the basis of present design of aircraft with regard to the passengers' safety will look rather silly 10 years from now when the passengers' safety will have received some attention. It is certainly on most designers' lists to look into, and there is so much to be done that we can look forward with confidence to much less a casualty list in crashes than has been the case heretofore.

"As to comfort and convenience of air travel—here is where every air-line passenger can qualify as being an expert on suggestions. I don't know where to begin, there are so many. The reading lights are poor on most air liners. There were a few DC-3's (I believe in TWA service at one time) that had a small shelf on the lower frame of the window where one could put reading glasses and other personal effects. Why this was not continued or made almost mandatory on every air liner is a mystery to me. The question of baggage handling is another one. Why the elaborate checking system? Why not have porters accompany the luggage to the plane, or a person carry his own, and have them checked in a baggage compartment in the plane and delivered in the same way? The Convairs were the first to give some thought to this, and the convenience is great. From Washington to New York, for example, one frequently waits 20 to 30 min. from the time the plane lands until the baggage is received in hand. Progress in all these items is being made, but there are still many worthy of consideration. An important new difficulty will arise when we get into the 600-m.p.h. jet-transport class, and that is structural shock absorbing to take up the sharp blows, stresses, and bumps that will come from gusts and turbulent air at this high speed.

"The fourth point listed above was that of the importance of a great air transport industry to this country in national defense. To emphasize this, we must digress a moment into war considerations.

"We hear much of, and more or less accept at the present time, the concept that strategic bombardment—the destruction of the enemy's home grounds, factories, roads, bridges, and everything else he has—is the way to wage war on an enemy and is the only real expression of *air power*. The time has come to question this and to question it seriously. In the light of history, World War I was a static trench warfare operation. World War II was a movement in the air for bombardment on land and sea with air cover—enormous seaborne oper-

ations—and then the blasting by tank columns and infantry through obstacles and through enemy territory by ground approach. Air warfare in the recent war was really long-range artillery. What will the third world war be? No two wars have ever been alike in recent history. Would there be a faint possibility that this next war will really be an air war in which air envelopment, air-borne operations, and air approaches play the dominant roles? Before appraising this, we must look at some new developments and see what they offer. The most important one is the jet engine. Too many of us merely look on the jet engine as a way of obtaining a faster airplane. Maybe that is not its importance at all; *it might easily be more important to realize that the jet engine gives us the first opportunity we have had to build an armored airplane successfully!* A flying tank could not be built heretofore (I was involved years ago in the design of one) because the propeller always remained vulnerable and therefore the design made no sense. But with the advent of jet engines, we can now design an aircraft as heavily armored as any tank, with multiple wing-spar construction that would take much punishment, which could engage a land tank in warfare from the air. We also have in the offing, as already mentioned, the possibility of induced airflow for slow airspeed operation of jet-equipped aircraft. If we combine the two, we are apt to find a change in the character of war, because we will develop Air Power in terms of operations that will not need elaborate landing fields and will have aircraft with armor to engage land defenses at close range and to protect air-borne operations of troops and supplies.

"When we come to this change, we cease to require land approaches to an enemy target in order to descend upon it, to seize it, and to exert our will upon it. This kind of warfare would mean that the futility of strategic destruction, resulting as it does in such a problem of devastation of areas and people to take care of afterwards, could be given up and, instead, we would enter upon a war having a real Power by Air, the objective of which is to kill or capture the soldiers of the enemy and the workmen making munitions but not to destroy the factories, the wealth of the country, the means of livelihood, the fields and farms, roads, bridges, and artistic antiquities worthy of preservation for the good of the world.

"Military envelopment of this character would require aircraft in huge numbers of all types and would literally put the entire army into the air. A visitation to arrest war activity by an air-borne envelopment would not need to contemplate holding a place. Once the job is done of stopping its operations by killing or putting the operatives under arrest, the invading air force takes off and returns to its base. In the end, we make it extremely unhealthy for an enemy citizen to either take up arms as a soldier or to take up his position at a lathe as a munitions maker. Air Power then becomes a real police power, and the nation that has the largest air transport background would be the strongest one in a war of this character. The air-borne operations that

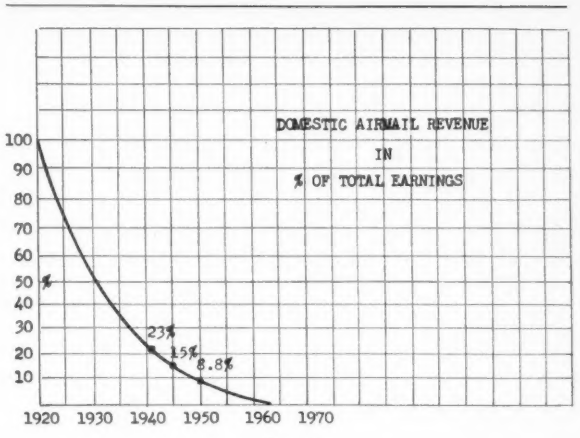


FIG. 6.

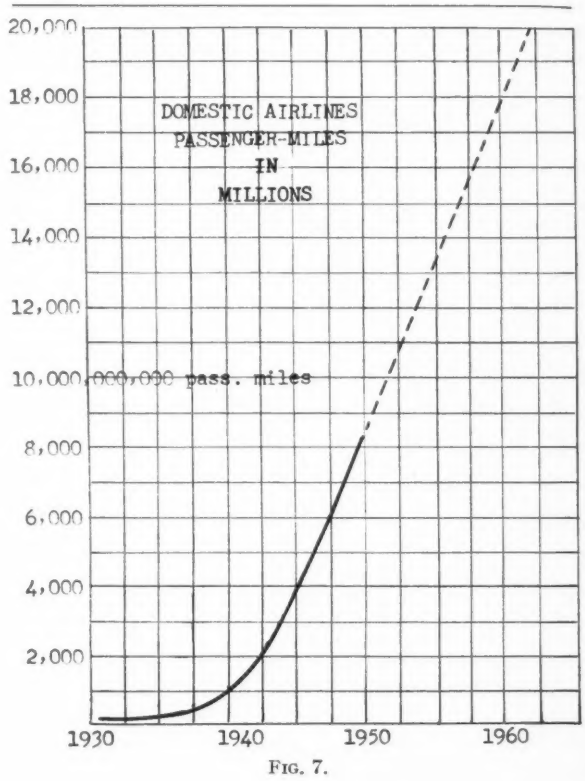


FIG. 7.

have been done to date are merely scratching the surface of what can be done if we want to use the indestructible air road as a means of access to putting the enemy out of commission. A further reason against dependence upon strategic bombardment alone (or in great measure as the principal war-making power of the nation) is that in this year 1951 it would be living in a fool's paradise to imagine that an enemy by now would not have many factories and important installations underground and camouflaged in a way to negate strategic bombardment, even including the atom bomb.

"It is of further interest in this connection to recall that even after the devastating strategic bombardment of Germany, which was so evidenced by the rubble that

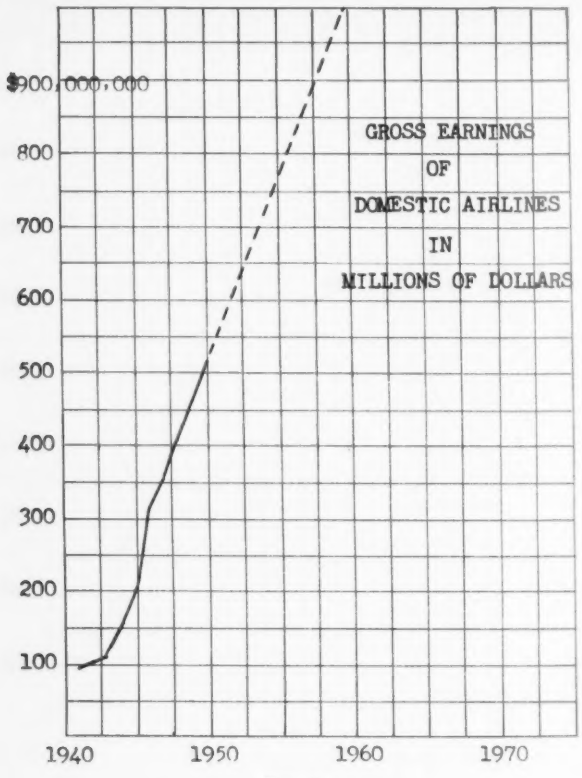


FIG. 8.

was left, there still was sizable production going on in Germany right up until the end of the war. Studies of World War II since then have brought out many interesting facts, such as the fact that a U-boat in commission proved to be a much more worthy target than a U-boat under construction, because what really stopped the U-boat warfare was the destruction of the crews, not of the materiel. It is important in appraising air transport development for us to give consideration to these war aspects if we are to be realistic.

"Air transport will develop only for two reasons—either privately because there is big money to be made in it or with Government assistance because it is so essential for national defense that the Nation will demand that it be developed to the full.

"We can expect, therefore—in fact, our people should demand—every possible encouragement to a vast increase in air transport. Any obstacles in the way should be looked at with a cold and unsympathetic eye. There is, for example, the possibility of regulatory functions increasing (as they are apt to do in a democratic bureaucratic Government) to too great a degree. A future C.A.A. must be watched carefully to avoid any hampering activities on development and to be sure that it helps along on the road of new enterprise by not interfering too much or dictating too many bureaucratic hurdles. To enable new items to be worked on by private enterprise, the prosperity of the air lines should be encouraged and not looked at from the standpoint of their being subsidized by air-mail subsidy and, therefore, subject to close supervision on profits.

"In these various connections, let us see what the future might look like. To begin with this very subject of air-mail subsidy—the total of earnings for the year 1920 was all air mail, and we start here to project a curve and find where we were going through the thirties and forties and on into the future (Fig. 6). By 1970, the proportion of air-mail revenue to total revenue will have gone down to less than 1 per cent of the gross earnings of the air lines and will have become completely negligible. This means emancipation from Government-babying and an industry that can stand completely on its own feet, unless, of course, we are supine enough and cowardly enough to have allowed Socialism to enter our happy picture in America as it is trying so hard to do. If we project the domestic passenger-mile operation figure on a chart, we can visualize the startling growth and find that by 1960 we should be running a business domestically of 20,000,000,000 passenger-miles a year (Fig. 7).

"With what slim data are available and using a reasonably optimistic forecast line, we can see that by 1960 the gross earnings of the air lines will be over $1,000,000,000 (Fig. 8). Cargo carried on the domestic air lines themselves has been sufficiently recorded to give some kind of a base for predictions thereon, and this would indicate that by 1960 we will be carrying 600,000,000 cargo ton-miles (Fig. 9). This, however, is independent of cargo carrying by independent air lines,

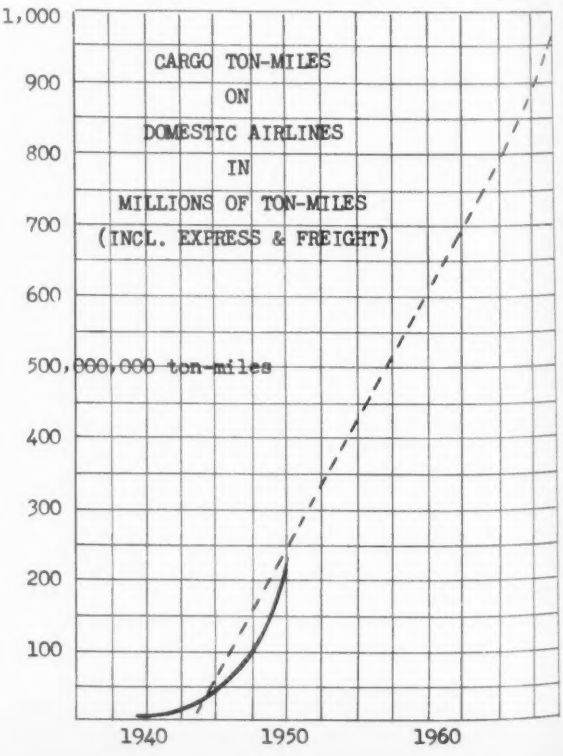


FIG. 9.

such as Slick, Flying Tigers, and the other growing operators in this field.

"An interesting item that is often considered, and in a confusing way, is the percentage of Pullman travel that is represented by air travel. The usual charts on this indicate the great increase from 1946 on, and, if this increase were to continue, one could easily draw a chart to show that by 1970 the air lines would have taken away practically all of the business from the Pullman Company. However, this does not happen to be the case for the simple reason that the Pullman Company is still doing about the same amount of business and, of course, the real reason is that air-line traffic represents, in great measure, the tapping of a new field. When some of the developments now in the offing come to fruition, air travel from home to home or office to office will tap so many new markets that to predicate a study of the future on what Pullman or steamship travel did would be about as sensible as to have predicted automobile traffic in the horse and buggy days. Meanwhile, of course, we have many other new developments in the offing which could almost be the subject of an additional lecture to cover them at all adequately. But in closing I will mention a few that need study and proper appraisal and definitely have great promise. There is, of course, this new question recently reopened by the advent of several developments in the use of seaplanes—landing fields right near the hearts of the biggest cities, easy access to docks, and many of the old deficiencies of seaplanes in comparison to land planes completely wiped out with the advent of jet engines. The seaplane is now going to be a faster and lighter plane than the land plane. On skis it will land on extremely rough water, and, for the same power loading, its take-off will be better than wheels. We should not refer to these aircraft as seaplanes but as water-based airplanes.

"There is also the 'pack plane' development that is promising in cargo-carrying operations as well as in war. On cargo operations is it certain that we should not give another look at the glider train? During the war, the great mistake was made of appraising the economy of glider trains without realizing that, for war reasons, the wing loading of the glider was made much lighter than the wing loading of the tow plane, which rather vitiated any advantages to be gained. When properly designed, a glider train can offer the same cargo handling advantages a train does on a track, particularly since retrieving loaded gliders from the ground can be easily worked out so that the tow plane never really has to stop in its long distance route but merely disposes and picks up loads while still on the wing.

"One of the most important additional reasons for looking so thoroughly into jet configurations is, as already indicated, that the jet flow should prove to be our major source for induced wing flow over the wing to slow down landing speeds and get us into smaller and nearer airports.

"Rocket take-off techniques are in their infancy. They may prove an important adjunct to air transport operation, and, while it is true that jet engines cannot use the reversible pitch propeller braking check, reverse directed rockets could accomplish the same thing.

"Have we given enough thought to refueling in flight? Its possibilities in improving the ton-miles per year delivered by an air liner, which is the food on which an air-line company lives, is intriguing to say the least.

"While we are doing all these fancy new things, let us not overlook the noise problem. At this time, it looks like a major headache.

"This brief survey, therefore, can only be concluded with the expression of a great optimism—our troubles of today are all clearly solvable and the possibilities of the future are immense."

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Investigation of Flight-Flutter Testing Techniques

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ABSTRACT

As the concern over the flutter problem in current designs increases, one sees that high quality flight-test information would be a valuable aid in predicting the flutter speed with greater certainty. Such testing must be in the speed range below flutter and would be employed in correlation with theoretical calculations. Since past attempts to collect subcritical aeroelastic response data have been largely unsuccessful, a survey was made to determine the failings of the techniques employed. The survey indicated that greater excitation was required to provide response signals larger than the signal from random aerodynamic and electrical disturbances.

A wind-tunnel program was instituted to determine the practicability of proposed improvements in technique by applying them to a typical model wing. Two excitation methods were selected for development. Sinusoidal responses of suitable magnitude were obtained by installing large rotating unbalances in tip tanks; also, acceptable response amplitudes were provided by the use of externally applied force pulses.

The investigation demonstrated that either technique is practical for in-flight excitation. From the numerical results, the magnitude of excitation required to produce satisfactory amplitudes on current aircraft types is estimated. The relative merits of each method under varying circumstances are discussed in the light of the test results.

INTRODUCTION

IN THE REALM OF AEROELASTICITY, certain of the phenomena do not lend themselves to direct determination in flight because of their destructive nature. An attempt to verify the flight-flutter speed, for instance, could be expected to result in the loss of the airplane and perhaps its pilot. This is unfortunate, since it becomes increasingly important to determine the flight-flutter speed as closely as possible to avoid unnecessary restrictions that might prevent a high-performance aircraft from utilizing its full capabilities in operation. In those critical circumstances in which calculations cannot be trusted, where major incongruities exist between the actual conditions and the assumptions on which the calculations are based, or where the calculated results show marginal safety, the higher quality information from flight test would be useful in refining the prediction of the flutter velocity. Since it is only possible to collect data on the aeroelastic behavior of an aircraft in the subcritical range of flight speeds, the flight information cannot be employed directly to determine the critical velocity, since this would necessitate an extrapolation of the trends indicated in the data over exactly that portion of the speed range where rapid shifts in these trends are to be expected.

One can perform calculations using various methods currently available from which the subcritical characteristics, as well as the critical velocity of the aircraft, can be predicted within the limits of the theoretical assumptions. In addition, given time and money, one can obtain data through the whole velocity range from dynamically similar models in the wind tunnel. If sufficient data of high quality could be obtained from flight testing in the range of speeds below flutter, a correlation could be attempted between the response predicted by calculations and model tests and the response observed in flight. Of course, such a correlation could only be drawn between equivalent procedures; whatever method of excitation is applied in the collection of flight data must be simulated on the model and in the calculations.

Neither calculations based on theory nor wind-tunnel testing on models can be expected to yield consistently dependable results, in view of the number of assumptions and approximations required. Oscillating wing theory is deficient in those phases in which interest is current. Compressibility corrections in the subsonic range[1, 2] cannot be extended into the range of present concern; the actual transonic range is beyond the scope of current approaches, and none of the supersonic theories[3–6] has been checked well enough to engender any confidence.

With an increasing tendency toward low-aspect-ratio aerodynamic surfaces on high-speed aircraft and missiles, it is unfortunate that finite span effects are not more clearly understood. Swept surfaces are a step further from solution, and no approach is available to handle the aerodynamics of surfaces such as delta wings, which deform more nearly as plates. Boundary-layer, separation, and wake effects cannot be incorporated as yet, and the aerodynamic forces and moments on oscillating tip tanks or nacelles can only be included in a most approximate fashion.

Presented at the Aeroelasticity Session, Nineteenth Annual Meeting, I.A.S., New York, January 29–February 1, 1951. This paper is derived primarily from a Sc.D. thesis submitted by M. D. Schwartz at the Massachusetts Institute of Technology in September, 1950. The thesis was written on research performed in an investigation sponsored by the Bureau of Aeronautics, U.S. Navy, under Contract NO(a)s-10921.

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The representation of the structure also requires simplification if analyses are to be kept within bounds of reason. The amount of work required to represent irregular and discontinuous structural characteristics or mass distributions makes such analyses unattractive. The basic concepts of deformable structures do not cover currently popular low-aspect-ratio, swept, and delta wings. Although it becomes increasingly important to consider airplane modes in the aeroelastic problem, the complexities required for such an analysis make it impractical, except by means of automatic computing equipment.

Experimental investigations of particular airplanes by study of dynamically similar models in the wind tunnel suffer from many of the same drawbacks. It must be noted that flight Mach Number, Reynolds Number, and Prandtl Number cannot be concurrently simulated except at full scale, and the effect on the flutter condition of variations from the flight values is not known. Especially in the case of tip tanks and nacelles, where separation characteristics probably have a major influence on their effect on the flutter condition, disregard of Reynolds Number changes could be misleading.

Attempts to introduce irregular structural characteristics result in complex and expensive models. Efforts to represent completely elastic airplanes lead to research investigations directed toward developing appropriate tunnel support systems. Also, methods of model construction must be carefully selected so that the proper values of structural damping will result.

In the past, attempts have been made to predict flutter speeds on the basis of subcritical flight-test data, supplemented by theoretical and experimental information. For the most part, these tests have been unsuccessful, since the quality of the data obtained from flight test has not been good enough to serve as a basis on which to predict flutter. A study of the literature shows that most of the difficulties that have been encountered have arisen from the failure to provide sufficient excitation to the aircraft so that the response signals would definitely exceed the signal from random aerodynamic and electrical disturbances. The problem, then, seems to be the development of satisfactory and practical methods of excitation, capable of producing sufficient response amplitudes in the structure.

On the basis of these considerations, this investigation was instituted to attack the situation in its many aspects as a research problem. A survey of pertinent literature was undertaken to classify the various approaches that had been used or proposed and the difficulties encountered in their application. Following this analysis, those methods that showed greatest promise for development were selected for further investigation. This selection was based on practical considerations, such as the time and modification required on the airplane to install the equipment, its complexity and expense, and the time and effort required to perform the testing. The theoretical justification for each of the selected approaches was carefully considered. A comparative experimental investigation was set up to evaluate the relative merits of the most promising approaches from the point of view of applicability, practicability, and safety by applying them to a model in the wind tunnel. The ultimate objective was to recommend particular techniques for use in flight flutter testing, dependent on the quality of data required, the modes to be investigated, the type of flutter indicated, and the relative abruptness with which the instability is expected to develop.

Background of the Problem

An extensive survey of available literature was undertaken to collect information concerning attempts that had been made toward flight-flutter testing and to evaluate these approaches on the basis of their results and their attendant difficulties. A bibliography appears in reference 7, which discusses the literature in detail.

A survey trip was made to visit most of the individuals in industry or in Government research who are directly concerned with the flutter problem. Through extensive discussions, it was possible to obtain information concerning experiences with flight-flutter testing, as well as opinions regarding the development of techniques and equipment. Many of the companies had attempted flight flutter testing of a simple sort with mixed results. The individuals interviewed were almost unanimous in feeling that flight flutter testing techniques needed further development, since the increasing importance of the flutter problem would require incorporation of flight data in the prediction of the critical speed for future designs, especially in view of the speeds involved, where calculations by any proved method break down.

The fundamental conclusion drawn from the sources studied was that no flight-flutter test program to date has actually succeeded in providing high quality information with which calculated results or model test data could be correlated for refinement of the prediction of flutter. The major obstacle has been the inability of the forcing equipment to excite the structure to amplitudes high enough so that the response signals exceed the level of the aerodynamic and electrical hash. Early investigators were hampered by crude pickups and recording equipment[8, 9] as well as by insufficient understanding of the parameters on which the most significant correlations could be based; however, presently available instrumentation equipment and increased acquaintance with the problem at hand have reduced these difficulties. It remains, then, to consider the methods of excitation which have been used or which have been proposed to determine which of them might be improved or altered to provide the excitation required.

Basically, two different philosophical approaches have been employed in flight testing for flutter. In one case, the frequency-response characteristics of the system have been studied with increasing air speed; in the other case, the nature of the transients of the

system has been surveyed as the critical velocity is approached.

By applying sinusoidal excitation to the aircraft structure at various frequencies and air speeds, it is possible to collect information that traces the development of the flutter condition and which can be matched against calculated and wind-tunnel test results in an attempt for correlation. This approach was originally suggested by von Schlippe,[10] although his intention was to extrapolate the flight-test data directly.

Various schemes have been proposed and employed to apply such excitation. The most popular method has been the use of rotating unbalance shakers,[8,11–13] although pneumatic and electromagnetic shakers have also been considered. It has been suggested that the aerodynamic forces produced by oscillating the aileron or an auxiliary airfoil in the air stream or other high-velocity flow might be employed. Another proposal has been the use of high-velocity jets of air or burned gases exhausting alternately in opposing directions.

Although rotating unbalance shakers have been widely used in the more formal flight flutter test programs, the magnitude of the forces actually required for steady excitation is so great that unbalances to produce them cannot be contained within the wing contour. Smith's results[15] indicate that the excitation required for a small, high-performance fighter is of the order of 500 lb. force vector, and, on this basis, it can be shown that a large bomber might require forces as great as 1,500 lbs. However, since many fighters are being designed with tip tanks and bombers are appearing with nacelles or external tanks well outboard, it does not seem impractical to consider mounting exciters in these positions.

The need for maintaining fixed phase between the shakers and the desire for rigid frequency control in the face of the unstable power requirement of a resonant system makes additional equipment necessary. The time needed to install the exciting equipment and its associated control systems is far more than is ordinarily available on an experimental model.

The electromagnetic shaker is attractive, since it offers complete controllability of the magnitude of the input, ease of control of the frequency, and simplicity of phase regulation between the shakers. However, to obtain reasonable forces from such an installation would require somewhat heavier equipment than is necessary for the rotating unbalance. The possibility of exciting the structure by oscillating the ailerons has a serious drawback, since it interferes with the pilot's control, especially when designed for symmetrical excitation. Producing the exciting forces by auxiliary airfoils introduces additional degrees of freedom to the system with aerodynamic effects, so that the aeroelastic characteristics of the system would be modified by their presence. Consideration of obtaining the required forces by air jets shows that an unreasonable mass of air is necessary.

If, instead of exciting the structure continuously, one only disturbs the system from equilibrium, the ensuing transient response is composed of all of the aeroelastic modes of the structure. By observing the changes in the rates of decay of the various modes as the velocity increases, information can be collected which relates to the growth of the flutter condition. This approach was first suggested by Grossman[14] in juxtaposition to von Schlippe's idea.

Several schemes have been employed to excite the transient response of the structure. Step functions and pulses have been introduced by control deflections or by flight through rough air, and some thought has been given to the possibility of applying external pulses, perhaps by means of explosive charges mounted on the structure, as Grossman originally suggested.

Flight through rough air has not proved to be a satisfactory technique, since the desired disturbances are not found in isolation. Since the aircraft is continually subjected to random excitation, there is no way to determine the point in time at which the structure is in pure decay. Although excitation through the control system has been widely used as a technique, it would seem to be too arbitrary for consistent results. The pulses introduced could not be expected to be repeatable, and the degree to which the various modes would be excited would be random. In addition, the pilot cannot apply a disturbance sharp enough and the control system cannot transmit a deflection sharp enough to excite interesting high-frequency modes adequately.

These points favored applying a deliberate pulse to the system. Consideration of the size of the force and the pulse time duration needed made a rocket unit sound feasible, since it is possible to closely represent almost any simple pulse shape desired by properly machining large single powder grains. In view of the magnitude of the force in the pulse, it would be necessary to investigate the possibilities of local failure, even on the wing structure.

There were questions to be answered regarding such an approach, since no work along this line is reported in the literature. The actual magnitude of the force pulse required and its duration had to be determined, and the attendant problems of synchronization and of uniformity of thrust and burning time had to be considered.

In comparing the two approaches, one significant difference is apparent. If the motion is to be observed continuously, a continuous input of energy is required. However, if only the transient response of the system is to be studied, it is only necessary to provide energy occasionally and in the amount required. As a consequence, it might be expected that the equipment for the steady-state excitation would be somewhat more elaborate than that required with the pulse technique.

Reviewing the several possible methods of excitation, it was seen that none used to date had been completely successful. However, some were seen to be inappropriate and not worth further consideration, while others showed promise for development. It is assumed that there is no interest in testing every new design for flutter but that it would be desirable to have well-

developed procedures available whenever it might be necessary to verify the flutter speed of a configuration. It is not possible to rule out all methods but one, since those methods that are practical in one situation may be totally useless in another. For instance, rotating unbalances mounted in the tip tanks on a fighter's wing would be a reasonable method of excitation for the fighter's wing modes. On the other hand, if it were necessary to investigate an empennage mode on a jet aircraft, where typically there is no space for equipment in the after fuselage and the fixed surfaces are thin, then some other method, such as the use of the external pulse, might be more attractive.

On these considerations, the method of excitation which seemed most suitable for development, of all of the methods that had been used previously, was the application of steady-state forcing by means of centrifugal shakers. If satisfactorily large forces could be produced by unbalances mounted in a tip tank, for instance, then this desirable technique could be applied on almost any of the newer aircraft. However, in contrast to this elaborate approach, the use of the external pulse produced by a rocket or special cartridge seemed worthy of consideration. Such a method should be inexpensive, uncomplicated, and easy to apply and would probably require a minimum of modification of the aircraft, as well as a minimum of time for actual test. For these reasons, it was decided to carry out parallel wind-tunnel investigations using these methods.

Two important points were to be considered in this investigation. Goland and Luke[16] suggest that the steady-state technique is more suitable for flight flutter testing, since, from calculations they have performed on a particular family of wings, it seems to give earlier indication of the development of a critical condition than does the transient response. It has also been stated that the study of the transient response might be misleading, since the presence of a lowly damped noncritical mode might obscure the response of the critical mode in the subcritical range, if it were well damped for these velocities.

Experimental Equipment and Procedure

An experimental program was set up to investigate the steady-state excitation technique by testing a model wing-tip tank combination in the wind tunnel by this method. The necessary mechanism, consisting of rotating unbalances and a motor to drive them, was designed and installed in the wing's tip tank.

The wing used was a 6-ft. semispan model with a 2-ft. root chord, a taper ratio of two to one, and a full-span aspect ratio of eight. The wing was of sectional construction; the only continuous members in the wing were two parallel magnesium alloy spars to provide bending stiffness. Interspar aluminum alloy torque tubes furnished the additional torsional stiffness required. The construction can be seen in Fig. 1, in which the wing is shown with the upper half of the wing sections removed. The tip tank used on the model wing was $6^1/_4$ in. in diameter and 3 ft. in length. The shell was constructed as a light fairing for the rotating unbalance system as can be seen in Fig. 2, where the top half has been removed to expose the rotating unbalance mechanism. The pertinent elastic and inertial characteristics of the wing and the inertial characteristics of the tip tank shell and contents are presented in reference 7.

The wing-tip tank combination was mounted at the tunnel wall on a support that was adjusted to allow only antisymmetrical modes to occur. The bending mo-

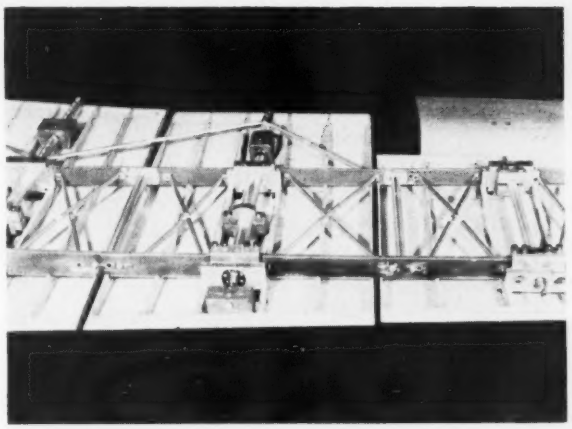

FIG. 1. Internal construction of the model wing.

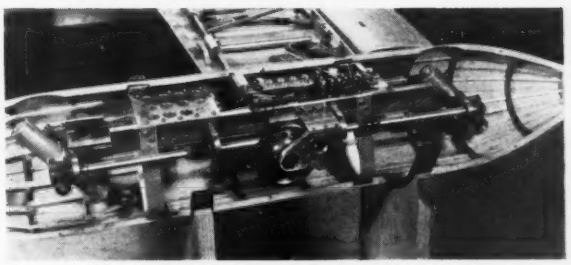

FIG. 2. Rotating unbalance exciting system mounted in the tip tank.

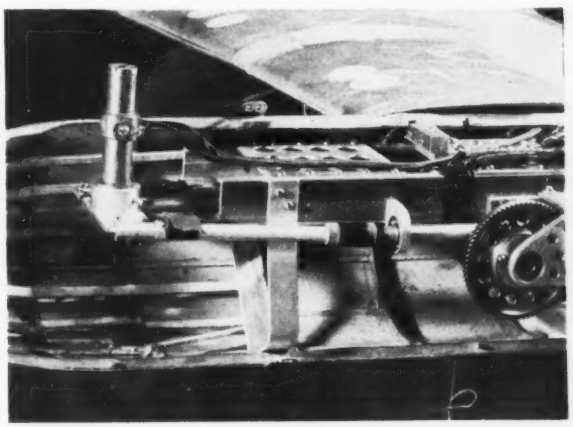

FIG. 3. Cannon mounted on the tip tank structure.

ment at the wall arising from the cantilever arrangement of the wing-tip tank combination was balanced out by soft springs in the support, giving the system an extremely low support frequency. The support is more completely described in reference 7.

The rotating unbalance system that was designed to excite the wing is shown in Fig. 2 as it was mounted within the tip tank shell. The mechanism was supported from the spars at the tip by the rigid structure shown, with a ball-bearing joint at the rear spar so that no torsional stiffness would be added to the wing at the tip. The rigid structure consisted of two upright aluminum channels with top and bottom chord plates. A controllable speed d.c. series electric motor was mounted below the channels to drive the shakers through a gear reduction box, drive shafts, universal joints, and spiral gears. A signal generator was attached to the motor so that the operator could read the excitation frequency continuously. The frequency of excitation was varied by adjusting a rheostat in the d.c. voltage supply to the motor. The top chord and web at each end of both channels was cut away, leaving a flexible leaf. The shakers were hung from these leaves, and strain gages attached to the leaves inboard of the shaker shafts measured the forces being transmitted to the structure.

To take full advantage of the space inside the tip tank, the shakers were disposed chordwise as far as possible and were phased to produce a sinusoidally varying couple at the tip. The detail design and construction of the shakers are discussed in reference 7.

To simplify the reduction of data and to improve the results, a composite bending-torsion accelerometer pickup was designed to record the translational and rotational accelerations at a point. The sensitive elements were R.C.A. mechano-transducer tubes as employed in reference 15. Their high sensitivities allowed designing the accelerometers with high natural frequencies to avoid the use of damping. Five of these composite pickups were disposed across the wing to furnish mode shape data. A bending accelerometer pickup was mounted near the root of the wing to determine roll amplitude of the half fuselage fairing. The design and performance of the pickup are discussed in reference 7. The bridge unbalance from each pickup signal was first filtered and then fed to a direct coupled amplifier, which transformed the voltage into a current. This current was applied to one of the galvanometers of a CEC recording oscillograph.

The forces applied to the structure by the rotating unbalances were measured by strain gages mounted on the flexible leaves from which the shakers were supported. The bridge unbalance from the force applied at the shaker shaft center line was proportional to the applied force. By employing a CEC System A bridge and amplifier, these signals were recorded along with the pickup signals. The vector difference between the signals was obtained by means of a proportional summing box and was also recorded, this being proportional to the moment applied to the structure. Resonant filters were used to suppress gear noise.

At successively increasing air speeds, the model was excited through a frequency range from 1.5 to 15 cycles per sec. Records were taken in short bursts at small steps in frequency, so that conditions were stabilized for each record. Beating and other sweep effects due to continually varying frequency while recording were thus eliminated.

For the external pulse testing, a small cannon was designed which used a charge of a few grams of zinc flash powder. The reaction to the exhaust pulse caused by detonating the powder was employed to excite the wing. The same wing-tip tank configuration was used in this phase of the testing as was used in the sinusoidal forcing phase, so that a common basis would exist for correlation.

It was stated above that almost any simple pulse shape desired can be simulated by properly shaped charges. The problem encountered here was that of producing the pulses of interest on model scale. The design of the cannon, as well as the selection of the powder for the charge, required considerable experimentation.

One of the features of the pulse technique which was to be considered was the possibility that a lightly damped noncritical mode might hopelessly obscure the subcritical response of the flutter mode in the velocity range where the flutter mode itself might be well damped. This condition did not exist here; instead the critical mode was always lightly damped. It was decided that if it could be shown that it was possible to collect information on another mode that was more heavily damped in the presence of this lightly damped mode, then the pulse method would have proved its merit. For this purpose, pulses of different time durations were applied to the system, based on a theoretical investigation of the effect of time duration on the response. For the lightly damped mode, whose frequency was always in the neighborhood of 2 cycles per sec., a rectangular pulse of about $^1/_4$-sec. duration was used. For the mode with more damping at about 11 cycles per sec., a pulse of about $^1/_{20}$-sec. duration was produced. The final model of the cannon is shown mounted in the tip tank in Fig. 3. Essentially, the cannon was a hollow steel cylinder with a removable aluminum screw plug at the top. This plug had a small orifice, so that the products of the combustion that occurred within the cylinder were exhausted at high velocity. The charge was detonated electrically by a heated wire that ran through the chamber.

At successively increasing air speeds, the model was excited by pulses. Several shots were fired at each air speed to ensure against bad firing, oscillograph misbehavior, and other similar conditions. Both long and short pulses were used to emphasize the high and low frequencies separately. Records were taken beginning just before the firing circuit was closed and continuing through several seconds of the response.

Theoretical Considerations

The theoretical justifications for the method of steady-state excitation are discussed in references 7 and 15. Numerous currently available methods of calculating the flutter speed can be used to provide theoretical results to match flight-test information; among them are Theodorsen's[17] typical section solution, the Air Force method,[18] and the Station Function approach.[19] However, the degree to which the results would correlate would be critically dependent upon the extent to which the existing conditions were matched in the theoretical description of the system used in the calculations.

The theoretical justifications for the method of transient excitation are argued at length in reference 7. In this reference a theoretical procedure is developed for predicting the time history of the response of an elastic wing in an air stream to an applied pulse. The method uses the Wagner description of the aerodynamic effects and the Station Function definition of the deformation shape and employs the Laplace transform procedure to handle the transient nature of the problem. In the development of this solution, it is shown, on the basis of simple considerations, that the most selective of elementary pulse shapes is a rectangular pulse with a time duration equal to half the damped period of the mode of interest.

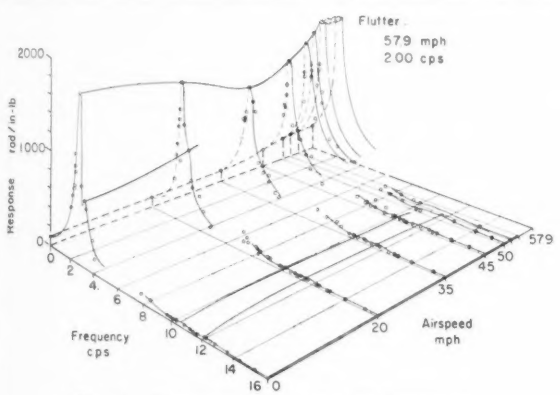

Fig. 4. Response vs. air speed vs. frequency.

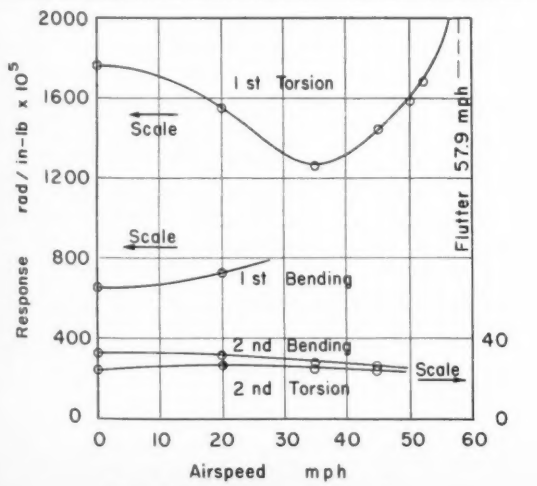

Fig. 5. Response vs. air speed.

Test Results

The results of the portion of the experimental program which related to steady-state forcing techniques are presented in the form of various plots that would be of use in correlating calculated results and wind-tunnel data with actual flight-test data in the subcritical range.

All of the mass characteristics of the exciting equipment had been absorbed into the tip tank characteristics, with the exception of the moment of inertia of the rotating unbalance masses about the elastic axis, since the inertia reaction of these masses in torsion was measured as a portion of the forcing moment applied. The presence of this additional inertia at the tip made the first torsion frequency of the total system lower than the first torsion frequency of the basic system, so that the torsion peak of interest fell between the bending and torsion peaks of the actual system. Its response was somewhat obscured by beating between these modes, and only a few points of value were obtainable in this region. This difficulty would have to be studiously avoided in a flight program.

Since the modes of the total system will be different from the modes of the basic system whenever large auxiliary masses are included in an external exciting system, any flutter analysis done for the basic system does not apply to the system with the exciters. Therefore, before flying the airplane with the external exciting equipment installed, a careful analysis would have to be carried out to prove the airplane to be safe for flight in the speed range to be investigated. It is not sufficient to keep the center of gravity of the auxiliary system well forward in hopes of making the flutter velocity for the total system higher than for the basic system. Instead, this technique can conceivably cause another combination of modes to become critical or can induce flutter at a lower speed. These difficulties could be avoided, however, by employing shakers that could be accounted for by disposable weight and which could be calibrated for force output vs. frequency.

The presence of the added inertia at the tip lowered the frequency ratio and caused the flutter speed of the total system to be 3.8 m.p.h. lower than the flutter speed of the basic system with the inertia of the shaker masses removed. However, this was of no great concern in the investigation. In the equivalent flight program no attempt would be made to approach the flutter condition closely.

Another factor limited the number of data points available in certain ranges, as well as the quality of the points obtained. The power requirement of a vibrating system in the vicinity of a resonance peak is unstable with ordinary power sources. However, it had not been feasible to incorporate feedback stabilization of fre-

quency in the laboratory equipment, and, as a result, certain points of interest could not be investigated. For a flight program satisfactory frequency stabilization would be possible by the use of Amplidyne or Rotatrol systems.

It is felt that the quality of the information obtained is higher than would be the quality of flight-test data, since the flight data would probably be taken with equipment that would cover the frequency range at a high sweep rate. This procedure introduces beating in the vicinity of a resonance and does not allow for lags in amplitude build-up in the structure. The resulting records are difficult to decipher.

The pertinent numerical results of the tunnel testing by means of the rotating unbalance equipment were as follows:

Still air coupled antisymmetrical modes:

First—first torsion	2.79 cycles per sec.
Second—first bending	3.25 cycles per sec.
Third—second bending	10.35 cycles per sec.
Fourth—second torsion	12.10 cycles per sec.
Flutter speed	57.9 m.p.h.
Flutter frequency	2.00 cycles per sec.

One of the most interesting plots on which to trace the development of the critical condition by steady excitation is presented in Fig. 4. It is a graphic representation of the aeroelastic response characteristics of the system, plotting the amplitude per unit excitation as a function of both frequency and velocity. The overwhelming predominance of the first torsion mode, which could be observed in the tunnel, is evident on this plot. Since the excitation equipment applied only a couple to the structure, the response of the bending mode is not obvious. The low peak at the first bending frequency indicates instead the frequency at which coupling effects transferred energy to the bending component efficiently enough to necessitate increased power absorption by the structure. The paucity of points near the first peak made it necessary to fill in the peak shape by the use of cross-plotting techniques.

The portion of the surface between 5 and 7 cycles per sec. has been left out, since an unexpected fore and aft resonance screened the response of interest by introducing false information to the pickups through coupling effects in the pickups themselves.

Data were recorded only up to 52 m.p.h. with the exciting equipment operating. Two points were obtained for the plot at 54.1 m.p.h. at the flutter condition for the total system. This curve and the curve for 57.9 m.p.h. have been drawn only to fill in the picture, although they are not actually defined by points.

The dropping off of the first torsion response in the medium air speeds is clearly shown with its subsequent increase toward the flutter condition. It was not possible to identify the bending response separately beyond 20 m.p.h. The modes of higher order do not display as marked an amplitude change but tend to drop off slowly with increasing air speed.

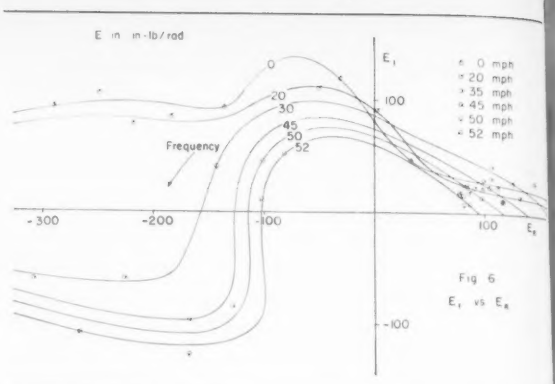

Fig. 6
E_I vs E_R

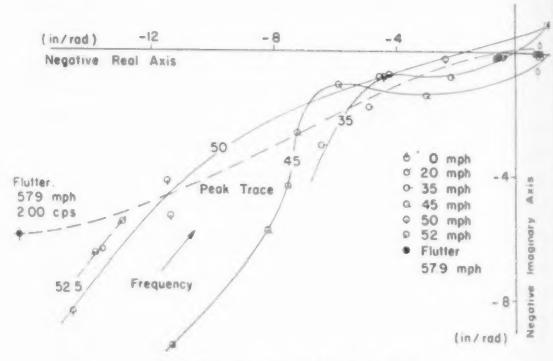

Fig. 7. Bending/torsion polar.

A projection of the peak traces of the three-dimensional plot on the response-velocity plane appears in Fig. 5. The initial development of the flutter mode from the low torsion mode is indicated at about 35 m.p.h., at which point the curve first takes on a positive slope. For this particular configuration, this earliest warning of an approaching instability occurs somewhat earlier than would ordinarily be expected.

One important characteristic of the response not presented in the above plot is the phase between the excitation and the motion, which demonstrates whether the excitation is supplying energy to, or extracting energy from, the structure. A means of incorporating this information for correlation is to plot an excitation/response polar representing the vector excitation divided by the vector response of the station at which the excitation is applied. This plot has been dubbed the E_I vs. E_R plot, since it presents the relation between the imaginary part and the real part of the excitation required to produce unit response amplitude. This scheme was first presented by Smith[15], who discussed it at length, although it had its earliest beginnings with Kennedy and Pancu.[20] The salient features of this type of plot are that it brings the peak responses close to the origin and that it ordinarily indicates a regular progression of curves for increasing velocities toward the critical condition. The peak responses are represented as the points on each velocity curve which fall at a minimum distance from the origin, indicating mini-

mum excitation required for unit response. Since the plot consists of smooth curves through the resonances, not as many points are required to define them as are required to trace out the shape of peaks on the three-dimensional response plot. The development of flutter is indicated by the approach of the curves toward the origin; at the flutter velocity, the curve passes through the origin. The low frequency portion of the E_I vs. E_R plot for this system is presented in Fig. 6. By examination of this plot, all of the significant features of the response can be identified, although it suffers from a scarcity of points in the same critical region as does the three-dimensional surface.

In considering the flutter of a typical section system, an item of interest is the relation between the bending motion and the torsion motion, since flutter commences at some discreet value of the ratio between the amplitudes and of the phase between the motions. This ratio and phase angle together have the properties of a vector and could be easily represented as a function of frequency and velocity on a vector plot. To probe the value of such a plot for correlating results from different sources, Fig. 7 was plotted for the tip displacements of the wing for frequencies in the vicinity of the flutter frequency. It is interesting to note that the development of flutter is indicated by a gradual approach of both the amplitude and the phase angle to the flutter values. The point on each velocity curve representing the torsion peak has been marked. It can be seen that these peak points form a smooth curve approaching the flutter condition.

The data obtained by the use of pulse excitation has been organized in the form of plots that would be of use for correlating information from diverse sources.

The equipment required to apply pulse excitation to the structure was much simpler and lighter than the rotating unbalance equipment. As a consequence, no difficulty was encountered in incorporating the mass of the cannon into the system as part of the disposable mass. Since this was the case, the system was unmodified and could be investigated directly.

If the transient response of the system following the application of a pulse is to be studied as a clue to aeroelastic stability, the attributes of the system which must be traced are different from those studied under steady excitation. The two fundamental items of information available are the frequencies in which the system responds and the rate at which the energy stored in the structure by the pulse is dissipated. Since it will be desirable to compare the results obtained by the two methods of forcing, it might be appropriate to remark that the frequency of maximum response and the frequency of decay are not the same. Therefore, the results obtained will not be identical, although the same trends should be indicated.

The pertinent numerical results of the pulse excitation testing were as follows:

Still air coupled modes:

First—first torsion	2.72 cycles per sec.
Second—first bending	3.43 cycles per sec.
Third—second bending	Not observed
Fourth—second torsion	11.6 cycles per sec.
Flutter speed	59.6 m.p.h.
Flutter frequency	2.02 cycles per sec.

It will be noted that the flutter speed listed here is higher than the speed listed for steady excitation. This was true since a small weight error was made in substituting the cannon for disposable mass. The listing of information on three of the four modes of the structure implies that satisfactory information was obtained on the response of these modes. This was indeed the case; by using long pulses to emphasize the low modes and short pulses to emphasize the high modes, as discussed above, consistent results were obtained. However, because of the inefficient cannon position used, information could not be obtained on the response in the second bending mode.

Since the interesting elements of data are the frequencies in which the structure responds and the damping indicated in its decay, it is reasonable to plot their functional dependence on velocity in three-dimensional form. Instead of the continuous surface that was developed by the steady forcing, the plot is made up of traces in space. Each trace represents the response in one mode, showing the frequency shift and change in damping with velocity. Such a plot for the system tested appears in Fig. 8. The relative stability of a mode is indicated by a high value of the damping ratio on this plot, where it was indicated by a low value of the response on the three-dimensional surface. The development of the flutter mode is shown as the first torsion mode demonstrates a continually lower decay rate, which finally becomes zero.

If there is a seeming inconsistency between this plot and the three-dimensional surface of Fig. 4, in that all of the modes indicate roughly equivalent values of damping ratio while they demonstrated considerable variation in response to steady excitation, this is due to the fact that the damping ratio plot is nondimensional, while the amplitude plot is not.

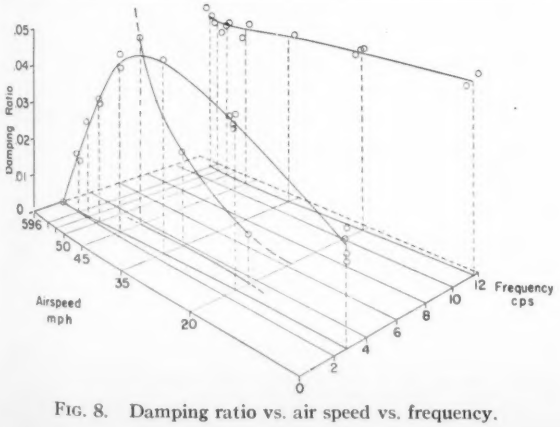

FIG. 8. Damping ratio vs. air speed vs. frequency.

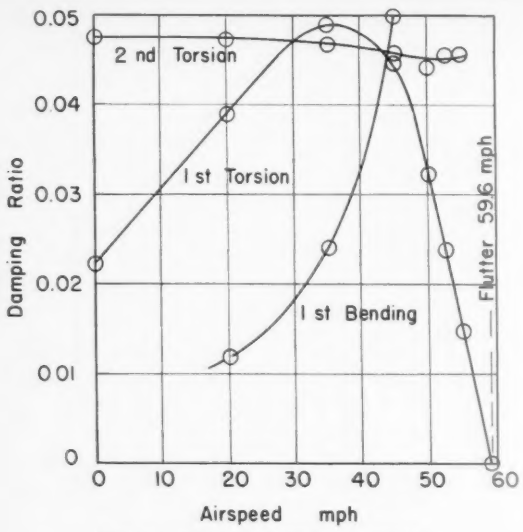

FIG. 9. Damping ratio vs. air speed.

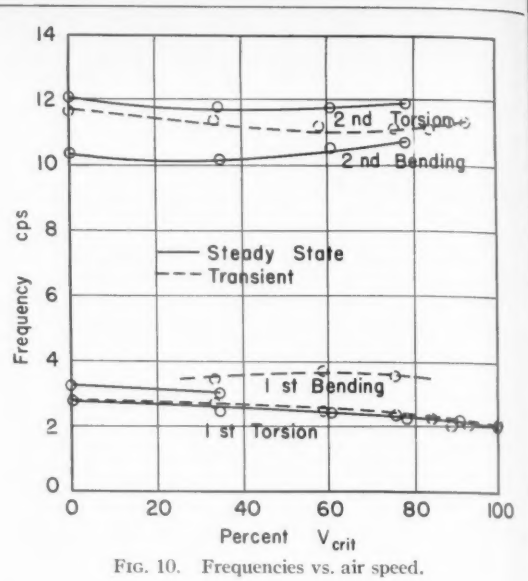

FIG. 10. Frequencies vs. air speed.

The actual values of the damping ratio for the various modes are plotted against velocity in Fig. 9. The damping present in the low torsion mode is seen to increase steadily with air speed up to about 35 m.p.h., reaching a maximum at about 37 m.p.h. and then steadily falling off as the flutter mode develops. It would appear that the simplest of extrapolations from the points at 52.5 and 55 m.p.h. would give a satisfactory estimate of the flutter speed for this case, even without the assistance of calculations. The low bending mode indicates increasing stability with velocity as far as it can be traced, even beyond the point at which the torsion mode indicates a decrease in stability.

Although this plot exhibits some of the features of the V-g diagram, which is used in estimating the flutter speed by the Air Force method,[18] it would be highly improper to compare these plots at any point but flutter. The plot presented here indicates the actual values of the damping ratio found for the system. The V-g diagram, on the other hand, represents the amount of structural damping which would be required for the structure to perform constant amplitude oscillations. In that portion of the subcritical range in which the V-g diagram indicates that negative damping is required, this analytical artifice cannot be related to the physical damping present by any means.

It was found that entirely consistent results could be obtained by determining the damping ratio from any of the readable traces within the limits of the accuracy with which the record traces could be read. The damping was also found to be constant throughout the decay within these limits. This would be so if the damping present were entirely viscous damping. It is certain that some energy was dissipated by structural damping, but its effect could not be seen in the decay.

One source of error which might be eliminated is the interpretative methods of record analysis employed on the pulse records. A more rational scheme might be based on an elaborate harmonic analysis of the response for the amplitudes of the various modes present in different portions of the decay. This might be successful, since such a small amount of damping is present that there is little amplitude change across a cycle. It is to be noted, however, that it is not the Fourier components of the response which are required. Some consideration of the methods of cross correlation which have recently been developed by Wiener[21] might also lead to improvements in data analysis techniques.

One of the most reasonable bases on which to judge the safety of one technique relative to the other is to consider how early in a test program either method would indicate development of a flutter mode. Perhaps the best feature on which to found this comparison is the velocity at which the critical mode no longer indicates increasing stability with increasing velocity, thus warning of an approach to flutter. By comparing Figs. 5 and 9, it can be seen that the zero slope points fall at almost exactly the same percentage of

TABLE 1
Model Results Scaled to Typical Full-Size Aircraft

	Weight, Lbs.	Span, Ft.	Critical Velocity, M.P.H.	Torsion Frequency, Cycles per Min.	Bending Frequency, Cycles per Min.	Pulse Force Time		Couple, Ft.Lbs.
						Lbs.	Sec.	
Model	100	12	60	165	195	1.0	0.2	0.2
F2H-1 Banshee	14,000	41.5	700	556	658	5,500	0.06	3,800
B-36	326,000	230	500	72	85	12,000	0.5	45,000

the critical velocity. Therefore, in this configuration, there seems to be no choice between the methods on this consideration. It is to be noted, however, that the plot from the pulse method results shows a much sharper variation with velocity.

A plot is shown in Fig. 10 on which the peak frequencies obtained by both methods are presented. The plot speaks for itself, since it indicates that both methods trace out identical trends, although the frequency values are slightly different.

Reviewing the information that can be obtained by either method of forcing and which would therefore be available for correlation with calculated results, it is seen that both methods are capable of developing the most important features of the aeroelastic characteristics. However, it is important to note that, wherever a discreet frequency point is available from the pulse technique, a whole frequency shape is available from the steady forcing. Therefore, there is a possibility of correlation on frequency shapes from this method which is not offered by the other.

To make any of the quantitative results of this program useful, it is necessary to scale them from model-size to full-size aircraft. It would be interesting, for example, to use the results to estimate the force pulse magnitude and the steady excitation magnitude required to perform satisfactory testing on current aircraft types. Representative of high-performance fighter types might be the F2H-1 Banshee, and an example of large long-range bomber types might be the B-36. Either of these aircraft could be tested by these techniques, since the Banshee mounts tip tanks and the B-36 has been modified to accommodate twin-jet pods at about the three-quarter semispan station.

Unfortunately, model theory has strict limitations. It is possible to talk about airplanes of the size, weight, and performance of those mentioned above, but this then determines their structural stiffnesses relative to the model, so that the scaled-up results may not match the airplane considered. Therefore, it is necessary to specify that the airplanes listed above are to be studied but that their frequencies match the scaled-model frequencies.

There is no direct manner in which to relate the turbulence found in the tunnel to the turbulence found in flight. Statistical methods are not applicable, since the tunnel turbulence level is repeatable in time, while atmospheric turbulence is a sensitive function of time and position. Obviously turbulent conditions would be avoided, and smooth air would be sought for flight flutter tests. As a result, it is not possible to predict what level of random accelerations would be found in flight records. This is unfortunate, since the magnitude of excitation required for successful flight testing for flutter is based on the specification that the response signal must exceed the aerodynamic and electrical hash signal by an acceptable factor. The only reasonable solution is to assume that the accelerations produced by turbulence scale by the same factor as do all other accelerations of the system. This is probably conservative, since the tunnel is not especially smooth.

In Table 1 the pertinent characteristics of the aircraft of interest and of the model are listed. The weight of a model of which the semispan model wing might be a part has been estimated at 100 lbs. Also, reasonable approximations have been made for the flutter speeds of the Banshee and B-36.

The scale theory that must be employed is the one that keeps the flutter parameter, $k = \omega b/V$, constant, since all of the aerodynamic effects are a complex function of this parameter and can only be simulated by staying at a constant value.

The pulse and couple magnitudes required for satisfactory excitation are listed in Table 1. They have been picked from the experimental records in the range of frequencies near the first torsion peak by requiring that the signal-noise ratio be greater than ten. This is arbitrary and probably conservative but is reasonable.

The magnitude of the pulse or steady couple required on the full-scale aircraft must be viewed in the light of the capabilities of the structure of the aircraft. The Banshee's 200-gal. tip tanks must weigh at least 1,500 lbs. when full, and the fittings and structure are designed for maneuvering loads several times the static load. The modified B-36 carries two Allison J-35's in a pod well outboard, and each J-35 weighs 2,500 lbs. dry and stripped. The resultant weight of the pod must exceed 10,000 lbs. On these considerations the excitation magnitudes do not seem to be unreasonable.

Conclusions

The following conclusions can be stated on the basis of the results obtained and the experience accumulated under this program.

(1) It seems entirely feasible to perform flight-flutter tests employing rotating unbalances mounted in tip tanks or other outboard installations to produce the required excitation. It would be more desirable to use excitation equipment whose mass and position could be accounted for by disposable mass, so that the characteristics of the system of interest would not be obscured by the modified response due to the presence of the excitation equipment. The system should be so designed that excitation of both the bending and the torsion response is possible.

(2) The application of force pulses to the structure by means of explosive charges appears to be a reasonable excitation technique for use in flight-flutter testing. It would be desirable to use both long and short pulses in the testing to emphasize the different frequency ranges in which the structure responds. The equipment should be capable of exciting both the bending and the torsion response and should be able to fire several times during a single flight.

(3) The greatest fund of information on the stability characteristics of an aeroelastic structure would result from the use of the steady forcing technique, since it

provides data throughout the frequency spectrum instead of at discreet response frequencies. The obstacles to the use of the method are the time and expense required to modify the aircraft and to install the equipment and the time required to perform the flight test.

(4) Use of the pulse technique to obtain data on the aeroelastic characteristics seems to be capable of producing results of equivalent quality, but only at the discreet frequencies in which the structure responds. The uncomplicated and inexpensive equipment required for flight excitation by this method could be quickly and easily installed in a small space on the aircraft. The method displays a particular advantage in those instances where space is not available for the installation of rotating unbalance equipment, as in the investigation of empennage modes, or modes of thin, high-performance wings without tip tanks.

(5) For this configuration, there seems to be no basis for the contention that the rotating unbalance technique provides earlier warning of a tendency toward instability.

(6) It is possible to obtain information on the several modes of the system using the pulse technique by applying appropriate pulse shapes to emphasize the modes of interest.

References

[1] Garrick, I. E., *Bending-Torsion Flutter Calculations Modified by Subsonic Compressibility Corrections*, N.A.C.A. T.N. No. 1034, 1946.

[2] Possio, E., *L'Azione Aerodinamica sul Profilo Oscillanto in un Fluido Compressible a Velocita Iposonora*, Aerotechnica, Vol. 18, No. 4.

[3] von Borbely, S., *Aerodynamic Forces on a Harmonically Oscillating Wing at Supersonic Velocity (Two-Dimensional Case)*, R.T.P. Trans. No. 2019, British M.A.P.

[4] Chang, C. C., *The Transient Reaction of an Airfoil due to a Change in Angle of Attack at Supersonic Speed*, Journal of the Aeronautical Sciences, Vol. 15, No. 11, p. 635, November, 1948.

[5] Garrick, I. E., and Rubinow, S. I., *Flutter and Oscillating Air Force Calculations for an Airfoil in Two-Dimensional Supersonic Flow*, N.A.C.A. T.N. No. 1158, 1946.

[6] Possio, E., *L'Azione Aerodinamica sul Profilo Oscillanto Alla Velocita Ultrasonore*, Acta, Pont. Acad. Sci., Vol. I, No. 11, 1937.

[7] Schwartz, M. D., and Wrisley, D. L., *Investigation of Flight Flutter Testing Techniques*, M.I.T., Aero-Elastic and Structures Research BuAer Contract NO(a)-10921, 1951.

[8] Bergen, W. B., *Experimental Investigations in Aircraft Dynamics*, Journal of the Aeronautical Sciences, Vol. 10, No. 8, p. 233, October, 1943.

[9] Bollay, W., and Brown, C. D., *Some Experimental Results of Wing Flutter*, Journal of the Aeronautical Sciences, June, 1941.

[10] von Schlippe, B., *The Problem of Spontaneous Wing Oscillation*, Luftfahrtforschung, Vol. 13, No. 2, 1936; also N.A.C.A. T.M. No. 806, 1936.

[11] Burow, H., and Roos, H., *Flight Vibration Tests*, U.S.A.F. Report No. F-TS-765-RE, February, 1948, from Deutsches Versuchsanstatt fuer Luftfahrt, February, 1940. Headquarters Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio.

[12] Cornell Aeronautical Laboratory, *Model SB2C-4 Airplane—Flight Flutter Investigation of Rudder Mass Balance*, Report No. SB-355-S-4, 1948.

[13] Curtiss-Wright Research Laboratory, *Flight Flutter Test of the Chance Vought F4U-1 Airplane—Phase 1—Flutter Tests of the Airplane in Six Guns, Overload Ammunition, No Wing Tanks Configuration*, Report No. SB-348-S-2, 1945.

[14] Grossman, E. P., *Flutter*, U.S.A.F. Technical Report No. F-TS-1225-IA, May, 1949, from Central Aero-Hydrodynamical Institute of Moscow, 1936, Headquarters Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio.

[15] Smith, R. H., and Schwartz, M.D., *Theoretical and Experimental Methods of Flutter Analysis*, Vol. II, M.I.T. Aero-Elastic and Structures Research Laboratory, BuAer Contract NOa(s)-8790, November, 1948.

[16] Goland, M., and Luke, Y. L., *A Study of the Bending-Torsion Aeroelastic Modes for Airplane Wings*, Journal of the Aeronautical Sciences, Vol. 16, No. 7, p. 389, July, 1949.

[17] Theodorsen, T., and Garrick, I., *Mechanism of Flutter, a Theoretical and Experimental Investigation of the Flutter Problem*, N.A.C.A. T.R. No. 685, 1940.

[18] Smilg, B., and Wasserman, L. S., *Application of Three-Dimensional Flutter Theory to Aircraft Structures*, Report No. 4798, U.S.A.F. Air Materiel Command, Wright Field, July, 1942.

[19] Rauscher, M., *Station Functions and Air Density Variations in Flutter Analysis*, Journal of the Aeronautical Sciences, Vol. 16, No. 6, p. 345, June, 1949.

[20] Kennedy, C. C., and Pancu, C. D. P., *Use of Vectors in Vibration Measurement and Analysis*, Journal of the Aeronautical Sciences, Vol. 14, No. 11, p. 603, November, 1947.

[21] Wiener, N , *Extrapolation, Interpolation, and Smoothing of Stationary Time Series*, The Technology Press, M.I.T., Cambridge, and John Wiley and Sons, Inc., New York, 1949.

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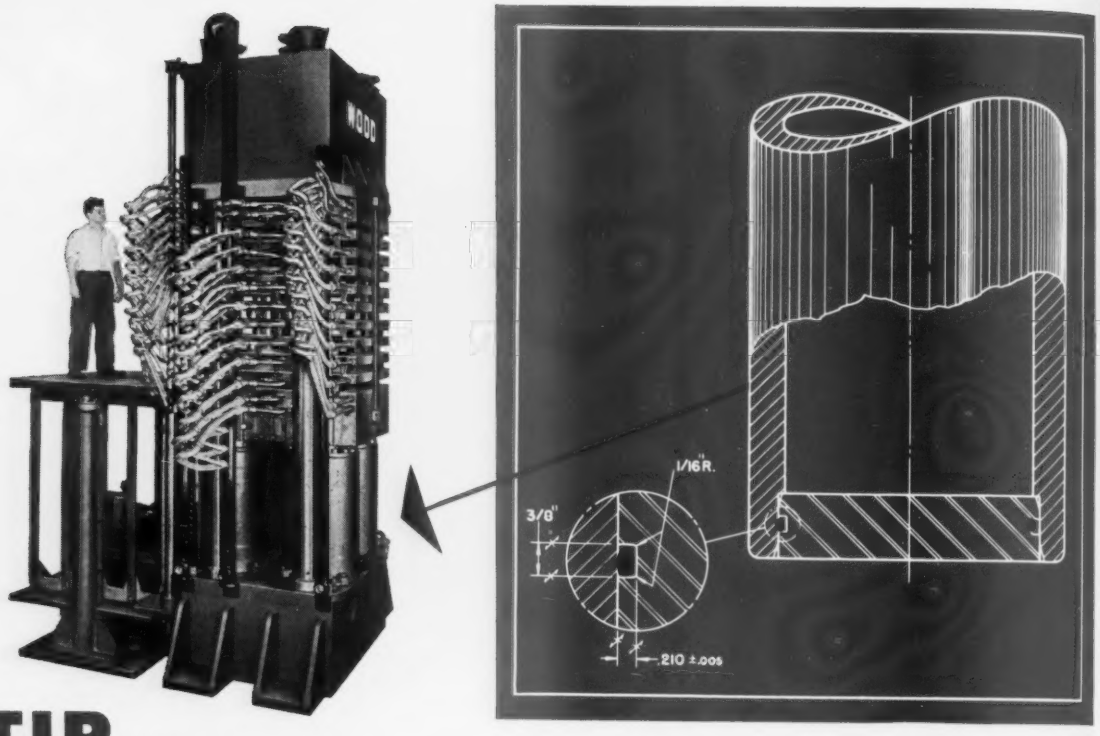

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I.A.S. Previews

Summaries of Current Papers Accepted for I.A.S. Publications

The Evaluation of Theoretical Critical Compression in Sandwich Plates

By

J. N. Goodier and I. M. Neou

Stanford University

Formulas for the critical compression of sandwich plates, which take into account everything that might influence the buckling load, are extremely complex. When simplicity is achieved by concessions in accuracy, the range of validity is not easily distinguished. The evaluations presented here use check points obtained from an "exact" analysis to test the accuracy of simpler formulas, with the result that one of the latter is found to be remarkably accurate over a wide range of geometrical and elastic parameters.

Allowable Compressive Stresses in Aircraft Structures

By

B. E. Gatewood and E. L. Williams

U.S.A.F. Institute of Technology and Curtiss-Wright Corporation, Respectively

This paper shows procedures for determining the allowable buckling and maximum compressive stresses in both the elastic and plastic regions for structural materials for which compressive stress-strain curves are known. In particular, curves are shown which are applicable for the aluminum and magnesium alloys. Detail procedures for obtaining the allowable compressive stresses in both the elastic and plastic regions are indicated for the following types of aircraft structure under compressive loads: (1) compressive buckling of flat plates, (2) compressive maximum of flat plates, (3) shear buckling of flat plates, (4) bending buckling of flat plates, (5) column stress for structural elements with stable cross sections (no local buckling), (6) interrivet buckling of flat plates, (7) compressive buckling of formed and extruded sections with local instability, (8) compressive maximum or crippling of formed and extruded sections with local instability, (9) column stress of formed and extruded sections with local instability, (10) bending buckling of formed and extruded sections with local instability, (11) bending maximum of formed and extruded sections with local instability, (12) compressive buckling of flat plates with stiffeners, (13) compressive maximum of flat plates with stiffeners, and (14) column stress of flat plates with stiffeners.

Preprint No. 308

Skin Friction and Heat-Transfer Characteristics of a Laminar Boundary Layer on a Cylinder in Axial Incompressible Flow

By

R. A. Seban and R. Bond

University of California at Berkeley

A solution is given for the case of the laminar boundary layer of an incompressible fluid of constant properties on the exterior of a cylinder with flow parallel to the cylinder axis. This case differs from the Blasius solution for flow along a flat plate by considering the effect of the curvature in a plane transverse to the flow direction. The local skin friction and heat-transfer coefficients for a Prandtl Number of 0.715 are evaluated and compared to the similar magnitudes for flat plate flow, and the effect of the curvature is shown to be significant in some practical cases. Recovery factors are evaluated, and this quantity is found to be insensitive to the effect of curvature of the boundary.

Summary of Recent Experimental Investigations in the N.O.L. Hyperballistics Wind Tunnel

By

Peter P. Wegener

U.S. Naval Ordnance Laboratory, White Oak, Md.

The N.O.L. 12- by 12-cm. continuous blow-down hyperballistics wind tunnel is briefly described. Limitations of present supersonic wind-tunnel techniques as applied to hypersonic wind tunnels are discussed. Measurements of pressures in the nozzle show that air condensation occurs if flow pressure and temperature fall below the saturation line of air. This condensation can be eliminated by preheating the supply air of the wind tunnel. Tentative experimental criteria on minimum supply temperatures to minimize air-condensation effects on the flow in the test section are given. The highest Mach Number achieved to date at N.O.L. on this basis is 8.25. The effects of air condensation on various standard measurement methods for the determination of Mach Number are given. It is found that only static-pressure and shock-angle measurements are sensitive to air liquefaction effects. Results of a thermodynamic treatment of the condensation process are presented. Finally, some measurements on boundary layers and possible flow separation at high Mach Numbers are given.

Preprint No. 329

Please do not order Preprints of these papers at this time.
See page 113 for Preprints that are immediately available.

The Lift Distribution on Low-Aspect-Ratio Wings at Subsonic Speeds

By

H. R. Lawrence

Cornell Aeronautical Laboratory, Inc.

A systematic procedure is developed for obtaining approximate integral equations from the linearized theory of a lifting surface in a steady incompressible flow. This procedure leads to a system of classification of the various theories currently employed in the calculation of lift distribution and to a new theory for the chordwise lift distribution over wings of low aspect ratio. A certain duality between the high-aspect-ratio and low-aspect-ratio approximations is exhibited by this classification system. The following conclusions are established for the special case of a rectangular wing, but the results are believed to be generally applicable.

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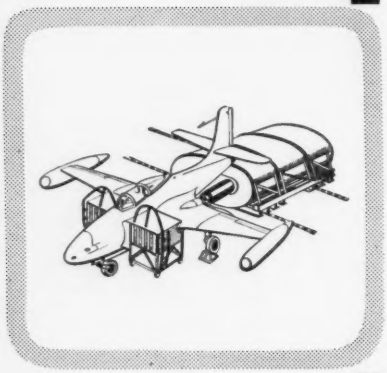

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(1) There does not exist a low-aspect-ratio analog to the infinite-aspect-ratio theory.

(2) The low-aspect-ratio analog to the Prandtl lifting-line theory is the Jones low-aspect-ratio theory.

(3) The low-aspect-ratio analog to the Weissinger lifting-line theory is the present theory.

(4) The Weissinger lifting-line theory and the present theory are unique among the theories under discussion in that they both approach the exact lifting-surface theory when the aspect ratio goes to infinity or to zero.

The theory developed for a rectangular wing is extended to more general plan forms. By reinterpreting the integral equation, the case of wing-body combinations and more general configurations may be solved. However, the régime of validity for these extensions of the theory must be established by comparison with test data.

The integral equation for chordwise lift distribution may be used in conjunction with the spanwise lift distributions of Jones and Spreiter to estimate pressures on the configuration only for symmetric spanwise loadings. In the antisymmetric case, an integral equation for the chordwise distribution of rolling moment may be used in conjunction with the antisymmetric Jones or Spreiter spanwise lift distribution to estimate pressures. The required integral equation for rolling moments is developed by a procedure analogous to the symmetric case.

A numerical method for solving the integral equations arising in the present theory is discussed and applied to calculations of the chordwise pressure distribution, lift-curve slope, aerodynamic center, and damping in roll of rectangular and delta wings for the aspect ratio range from zero to four. The results are compared with test data and show satisfactory agreement.

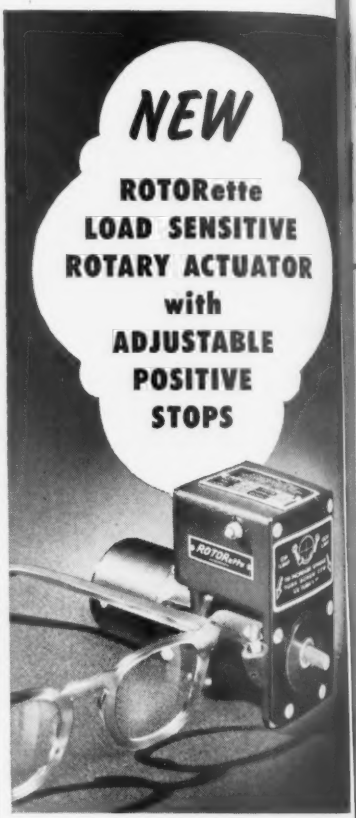
The results of the present theory as applied to low-aspect-ratio wings are valid only for small angles of attack. In a paper by Flax and Lawrence, a method is proposed for taking account of the nonlinear lift curve of low-aspect-ratio wings. A viscous cross-flow drag term $2\alpha^2$ is added to the lift coefficient and is assumed to act at the plan-form centroid of area. The present theory may be extended to large angles of attack by making use of this procedure.

Preprint No. 313

Gyro Pickoff Indications at Arbitrary Plane Attitudes

By
Leonard Becker
Lear, Incorporated

The error sensing device most often used in present-day aircraft having auto-



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pilot control—free or displacement gyros—generally gives pickoff indications at arbitrary plane attitudes for small deviations from these attitudes, which are functions not only of the departures about the axes which these pickoffs are supposed to detect but also of the departures about the other two axes. These functional relationships are calculated for a common arrangement of vertical and directional gyros for an arbitrary attitude of the plane and for various special attitudes that might occur in maneuvers. In the general case, the resolution of the pickoff signals to feed correctly the autopilot servos for stabilization purposes is indicated. Gyro interactions that would impair stabilization are shown to exist.

Exploratory Wind-Tunnel Investigation of Wings and Bodies at $M = 6.9$

By

Charles H. McLellan

Langley Aeronautical Laboratory, N.A.C.A.

Results of an exploratory investigation of wings and bodies at a Mach Number of 6.9 in the Langley 11-in. hypersonic tunnel are presented. Force data were obtained on a square and a triangular plan-form wing having 5 per cent thick diamond sections, on a circular cone-cylinder body, and on a semicircular cone-cylinder body. Pressure-distribution data were also obtained on the square plan-form wing and the circular body.

The results have been compared with calculations made by various theoretical methods. The more exact theoretical treatments gave overall force values in good agreement with experimental results. Measured pressure distributions departed appreciably from calculated results in some cases because of the influence of boundary layer.

Preprint No. 322

Aerodynamics of a Supersonic Rectangular Wing Striking a Sharp-Edged Gust

By

Theodore R. Goodman

Cornell Aeronautical Laboratory, Inc.

The method of C. S. Gardner for solving nonsteady finite wing problems at supersonic speeds is briefly described. An expression for the pressure is derived in terms of the velocity potential in the transformed variables used by Gardner. Nonsteady wing problems are solved, according to Gardner, by solving two three-dimensional boundary-value problems. In the case of the sharp-edged gust, the first problem is a symmetrical finite wing problem, and the second is an antisymmetrical problem based on the solution to the first problem. Expressions are derived for the pressure in the various regions on the wing, and these are shown to be conical. Finally, the pressures are integrated, and formulas are given for the lift and leading-edge moment as functions of time, aspect ratio, and Mach Number.

Interference Between Wing and Body at Supersonic Speeds—Theoretical and Experimental Determination of Pressures on the Body

By

R. H. Cramer

Cornell Aeronautical Laboratory, Inc.

Experimental data are adduced to show the pressure distribution on an axially symmetric body, aft of a lifting wing, in supersonic flow. Both the axial distribution of integrated lifts and the peripheral pressure plots are shown to be predicted to engineering accuracy by use of the linearized theory propounded by Ferrari, even when only a few terms are used in the Fourier development required by the theory. The theoretical curves were obtained by means of a new simplified solution to Ferrari's differential equation; it is expressed in terms of the hyperbolic functions of successive integral multiples of an argument so that the work of numerical computation progresses rapidly with the aid of standard tables.

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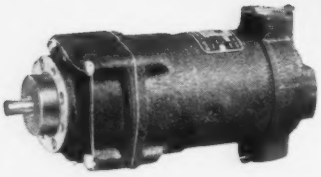

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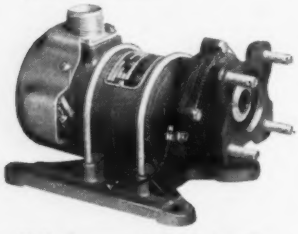

Helical geared fuel transfer pump motor having maximum output with minimum weight. For aircraft, but adaptable to other uses.

A motor engineered to the exact requirements of your product generally results in greatly improved product performance.
Lamb Electric Motors, built to precision standards of high quality materials, also make available: reduced *product* weight, increased dependability, compactness, improved appearance and lower cost. We shall welcome the opportunity to discuss these benefits in terms of your products. *The Lamb Electric Company, Kent, Ohio.*

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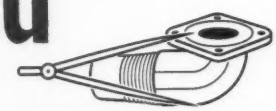
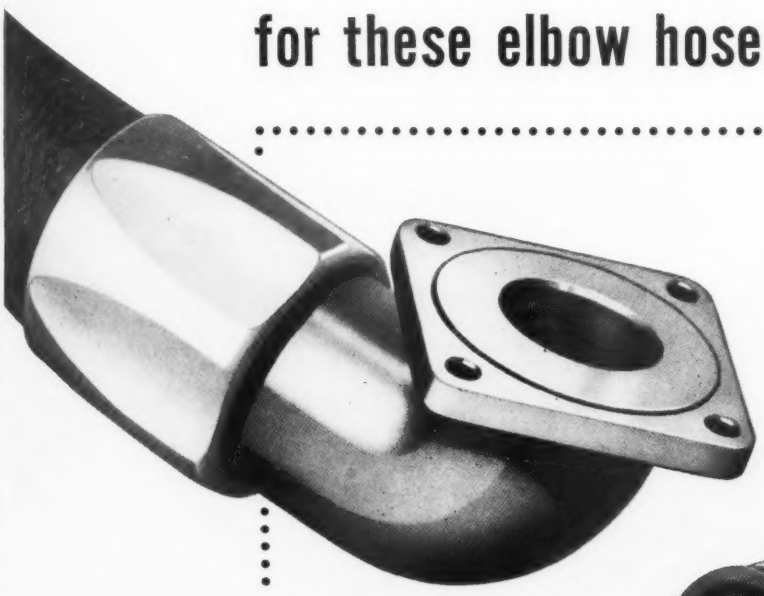
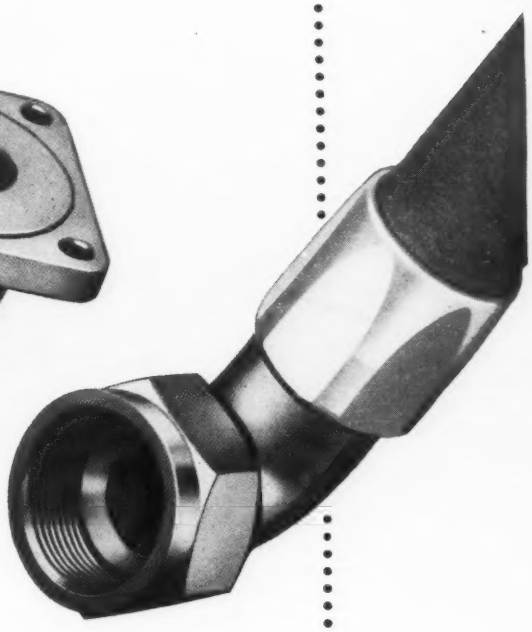
SPECIAL APPLICATION
FRACTIONAL HORSEPOWER MOTORS

You need less space



for these elbow hose fittings





Resistoflex hose assemblies with

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elbows fit in tight spots...

minimize turbulence despite short bend

ALUMINUM FORGINGS make the big difference in Resistoflex aircraft hose fittings. They save weight, of course. But equally important, they permit one-piece, more *compact* designs with *short* bend radius. These are machined with *true* internal bends. As a result, Resistoflex aircraft hose assemblies not only save space but also deliver full flow with minimum turbulence.

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RESISTOFLEX

CORPORATION

Belleville 9, New Jersey

I.A.S. News (Continued from page 7)

Necrology

(*Continued*)

basis on which to work. Applying the principles of the older science of naval architecture to the newer one of airship design, he soon became one of this country's foremost authorities on this subject. Throughout his many years of service as Principal Engineer (Lighter-Than-Air) in the Airship Design Section, he was active in the design of perhaps all of the Navy's airships. Just prior to his death, he had been working on the design of the Navy's latest airship, the ZPN built by Goodyear Aircraft Corporation.

Mr. Burgess had had numerous articles printed on the subject of airship design in various technical journals both here and abroad. In 1927, his book entitled *Airship Design* was published. This year, another of his books, this one on naval architecture, was scheduled for publication.

William G. D. Farmer

William George Devey Farmer, T.M.I.A.S., was fatally injured in an automobile accident that occurred last March just outside of Montreal, Quebec, Canada. He was 22 years old.

Born in Hamilton, Ontario, Bill Farmer attended Upper Canada College from 1944 to 1946. For the next 4 years, he was a student at the University of Toronto from which he was graduated in June, 1950, with a B.A.Sc. degree. He became associated shortly thereafter with Canadair, Ltd., and was employed there at the time of his death as an Assistant in Aerodynamics.

As a college student, Bill Farmer accepted various temporary summer positions. These included Aircraft Radio Technician with the Dominion Skyways, Ltd.; Stoker 2/c, R.C.N. (R.), at sea on the aircraft carrier, H.M.C.S. "Magnificent"; Assistant in the Joint Loans Division, Central Mortgage and Housing Corporation; and Laborer with certain engineering firms in Fairbanks, Alaska.

Bill Farmer is survived by his parents, Brigadier and Mrs. G. R. D. Farmer, as well as a brother, Richard, and a sister, Alison. He was a member of the Engineering Institute of Canada and of the Association of Professional Engineers for the Province of Ontario.

Walter H. Pearson

Walter Herbert Pearson, M.I.A.S., passed away last January at the age of 50.

A native of Plainfield, N.J., Mr. Pearson attended Newark Technical School and Franklin Institute, where he took a general engineering and mechanical course.

In the 1920's, Mr. Pearson was employed as an engineer by the Baldwin Locomotive Works, and during the next decade, in the 1930's, he was with the Bituminous Service Company as plant engineer. In 1939 he joined the staff of the Szekely Engineering Company as Chief Engineer. Three years later, he became associated with Kellett Aircraft Corporation, designing and projecting helicopter transmission systems.

At the time of his death, he headed the firm of W. H. Pearson and Son, Consulting Engineers, of Wayne, Pa. This business is being carried on by his son, Walter H. Pearson, III.

News of Members

▸ **Major Gen. Harry G. Armstrong** (F.), Surgeon General of the Air Force, was elected President of the Aero Medical Association at the meeting held last May in Denver.

▸ **Dr. Leslie A. Bryan** (M.), Director, Institute of Aeronautics, University of Illinois, was slated to go on temporary active duty with the Air Force as a reserve Lieutenant Colonel.

JOINS KOLLSMAN

Jay E. Browder (M.) was appointed to the position of Chief, Radio Communications Engineering Section, Kollsman Instrument Corporation, a subsidiary of Standard Coil Products Company, Inc. For the past 11 years, Mr. Browder was with The Sperry Gyroscope Company, Division of The Sperry Corporation, and at the time of his resignation from Sperry was Engineering Section Head for aeronautical radio equipment. He had previously been associated with Trans World Airlines, Inc., in its Radio Engineering Laboratory.

▸ **Ralph S. Damon** (F.), President, Trans World Airlines, Inc., was elected a Director of Strategic Materials Corporation.

▸ **Dr. Hugh L. Dryden,** I.A.S. Honorary Fellow, Founder Member, Past-President, and Editor, JOURNAL OF THE AERONAUTICAL SCIENCES, as well as Director, N.A.C.A., was awarded the honorary degree of Doctor of Science from Western Maryland College.

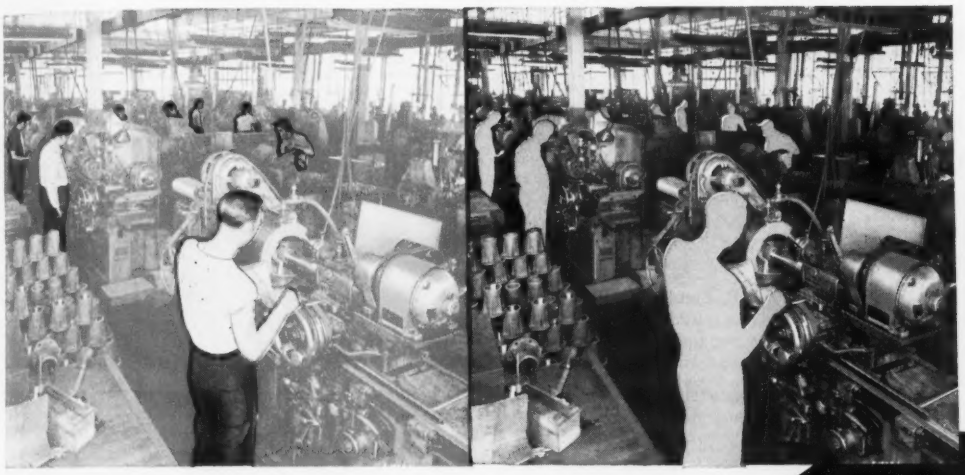
▸ **Walter Fitch** (A.M.), XB-47 Flight Test Inspection, Wichita Division, Boeing Airplane Company, has been appointed the Kansas Governor of the Soaring Society of America. Mr. Fitch built and flew a Chanute-type glider in 1922 when he was 16 years old.

▸ **William P. Lear** (A.F.), Chairman of the Board and Director of Research and Development, Lear, Incorporated, has been appointed the Communications and Electronics Adviser to the National Commander of the Civil Air Patrol. He will hold the rank of Colonel.

▸ **W. Randolph Lovelace, II, M.D.** (F.), Head, Section on Surgery, Lovelace Clinic, Albuquerque, N.M., was recently appointed Chairman of the Armed Forces Medical Policy Committee. Regarding the Lovelace Clinic, a new $350,000 research laboratory is to be constructed as a wing of the present clinic building.

▸ **Dr. Theodore Theodorsen** (F.), Vice-President and Dean of Engineering, Instituto Technológico de Aeronáutica, Rio de Janiero, Brazil, is a Consultant for the Air Research and Development Command.

the SKILL *the* FACILITIES



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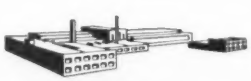
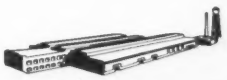

PLANT 2
Detroit, Mich.

PLANT 3
Hillsdale, Mich.


PLANT 4
Hillsdale, Mich.

ELECTED TO KEY POST

Charles Froesch, F.I.A.S., has been named Vice-President in Charge of Engineering for Eastern Air Lines, Inc. A native of Paris, France, he came to this country in 1912 at the age of 16 and was naturalized 7 years later. He has been with Eastern since 1935 as their Chief Engineer. Mr. Froesch, who is considered an authority on aircraft design, will remain at the air line's home office in New York City.

▸ **Col. Arnold D. Tuttle,** U.S.A. (Ret.), M.D. (M.) retired on June 1 from his position as Medical Director of United Air Lines, Inc. He will, however, still be associated with the company in a consultant capacity. Colonel Tuttle, who has been with United since 1937, is President of the Aero Medical Association.

Members on the Move

This section provides information on the latest affiliations of I.A.S. members. All members are urged to notify the News Editor of changes as soon as they occur.

Kenneth K. Bowman (M.), Assistant to Manager of Manufacturing, Aeronautic and Ordnance Systems Divisions, General Electric Company. Formerly, Assistant Manager of Engineering, Aeronautic and Ordnance Systems Division, G-E.

Dr. Stanley Corssin (M.), Associate Professor of Aeronautics, The Johns Hopkins University. Formerly, Assistant Professor of Aeronautics, Johns Hopkins.

Paul Domanovsky (T.M.), Aerodynamic Engineer "A," Chance Vought Aircraft Division, United Aircraft Corporation. Formerly, Candidate for M.S. Degree in Physics and Instructor, Theoretical and Applied Mechanics, Iowa State College.

Reed M. Dunbar, Jr. (T.M.), Aeronautical Icing Research Laboratory, Willow Run Airport, Ypsilanti, Mich. Formerly, Junior Project Engineer, Smith, Hinchman & Gryllis, Inc.

Dr. Laurence E. Fogarty (M.), now with Link Aviation, Inc.

Arthur C. Gilbert (T.M.), Senior Stress Analyst, Vibration and Flutter Group, Republic Aviation Corporation. Formerly, Vibration Engineer, Piasecki Helicopter Corporation.

Richard Greinacher (A.F.), Section Chief for Aviation, Military Technical Service, Federal Council of Switzerland. Formerly, Chief Aerodynamicist, Swiss Military Technical Service.

Boris S. Kudravetz (T.M.), Process Engineer, Day & Zimmermann, Inc., Consulting Engineers, Philadelphia. Formerly, Design Engineer, Aviation Gas Turbine Division, Westinghouse Electric Corporation.

R. Stanley La Vallee (T.M.), now with The RAND Corporation. Formerly, Aeronautical Engineer, United Aircraft Corporation.

Frederick B. Lee (M.), Deputy Administrator for Operations, Civil Aeronautics Administration. Formerly, Deputy Administrator for Program Planning, C.A.A.

Dr. Donald H. Loughridge (A.F.), Assistant Director, Reactor Division, Atomic Energy Commission. Formerly, Senior Scientific Adviser to Secretary of the Army, Department of Defense, U.S. Government.

Howard R. Moles (A.F.), Chief Engineer, Air Lifts, Inc. Formerly, Chief Engineer, Reaction Motors, Inc.

Hugh G. Nicholson, Jr. (A.F.), Administrative Assistant to the General Manager, Grand Central Aircraft Company. Formerly, Assistant to the Operations Manager, Grand Central Aircraft Company.

Frederick C. Phillips (M.), Aerodynamics Test Engineer, Helicopter Division, McDonnell Aircraft Corporation. Formerly, Professor of Aircraft Design, Institute of Technical Aeronautics, Brazilian Air Ministry, Brazil.

Michael K. Rastiello (T.M.), Senior Design Engineer, Machine & Tool Design Company, on assignment with The Glenn L. Martin Company. Formerly, Designer "B," Machine & Tool Design Company, on assignment with Lockheed Aircraft Corporation.

JOINS HAMILTON STANDARD

Turner A. Sims, Jr. (A.F.), has become associated with Hamilton Standard Division of United Aircraft Corporation in the capacity of Assistant General Manager. He was previously Vice-President of Fairchild Engine and Airplane Corporation and General Manager of Fairchild's NEPA Division. Mr. Sims, a native of Little Rock, Ark., and a U.S. Military Academy graduate, retired from the U.S. Air Force after 21 years of service in the engineering and executive branches of that division of the armed forces. He received his military pilot's rating in 1927 after completing his flight training at San Antonio, Tex.

Murray F. Southcote (T.M.), now Engineer, Aerodynamics Section, Northrop Aircraft, Inc.

Austin Wickwire (M.), Resident Engineer for Lockheed Aircraft Corporation, Rohr Aircraft Corporation. Formerly, Power Plant Design Engineer (Model P2V Compound Power Plant), Lockheed Aircraft Corporation.

Fred J. Wilhoff (T.M.), now Assistant Superintendent of Operations, Airborne Flower and Freight Traffic, Inc.

A. J. Williamson (M.), Vice-President—Manufacturing, Tube Reducing Corporation. Formerly, Plant Manager, Summerill Tubing Company, Division of Columbia Steel and Shafting Company.

Corporate Member News

• **Aircraft Gas Turbine Divisions, General Electric Company** . . . According to a recent announcement, an option to lease 50,000 sq.ft. of manufacturing space in Ludlow, Vt., has been taken as a part of the current plant expansion program for jet-engine production. New facilities are being sought for "parts manufacturing operations, including die-sinking." Ultimately, headquarters for the Aircraft Gas Turbine Divisions will be at the Lockland, Ohio, Plant. Other facilities are also being operated at Lynn and Everett, Mass.

• **AiResearch Manufacturing Company, Division of The Garrett Corporation** . . . The complete air-conditioning and pressurization systems for Avro Canada's CF-100 jet fighter will be supplied by AiResearch.

• **Allis-Chalmers Manufacturing Company** . . . A new mechanical power department has been organized.

• **Aluminum Company of America** . . . A 14-page illustrated booklet describing its East St. Louis, Ill., Research Labora-

(*Continued on page 49*)

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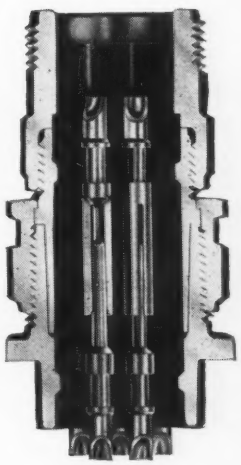

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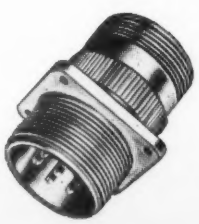

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American Helicopter Society News

Several new American Helicopter Society chairmen for 1951–1952 were designated during a meeting of incumbent officers on May 22 in New York City. One holdover from the 1950–1951 roster will be retained in an advisory capacity, but, in the main, new faces will appear during the subsequent meetings for the remainder of 1951 and for the year 1952.

H. S. Tremper, of Piasecki Helicopter Corporation, was elected Chairman of the 1952 Forum. Others elected were Charles W. Lefever, of Prewitt Aircraft Company, the Forum's Technical Chairman; J. E. Bieghle, of Sikorsky Aircraft Division of United Aircraft Corporation, Dinner Chairman; Tom Harriman, of Bell Aircraft Corporation, Membership Chairman; Ed Odlum, of The Kaman Aircraft Corporation, Chairman of Exhibits and Airshows; Warren Rockwell, of Hiller Helicopters, Chairman of Arrangements; and H. A. Haberer, of Bell Aircraft Corporation, Publicity Chairman.

The American Helicopter Society's 1952 Forum will be held in Washington, D.C., sometime during the spring. There were many complimentary expressions voiced concerning the time and place of the last meeting; therefore, it is believed that the same format will be followed for the coming meeting next spring. However, extensive preparation and discussion of plans are anticipated by the new officers which may lead to "something new to be added." The dates and location in Washington will be announced at a later date—i.e., after plans have been finalized.

Frank Piasecki, last year's President, will take the post of Awards Chairman. His success last year in reforming the award situation was excellent work and was gratefully received by all members. His theory of decreasing the number of awards to just three was accepted unanimously by the rest of the members of A.H.S. Warm praise was also heard for his untiring efforts to make the A.H.S. a successful and efficient group. With just three awards presented each year, competition will be keener, and the awards themselves will be enhanced in importance.

The three awards chosen by the Presentation Committee to be given each year are: the Dr. Alexander Klemin Plaque, the Capt. William J. Kossler Award, and the Honorary Membership Certificate Award.

The Dr. Alexander Klemin Plaque, donated by Mr. Piasecki, is the highest A.H.S. award. It is given for the most notable achievement of the year in the advancement of rotary-wing aircraft. The Capt. William J. Kossler Award is given for the outstanding achievement in practical application of rotary-wing aircraft during the past year. The Honorary Membership Certificate will be presented annually for the most notable and meritorious service in the advancement of helicopter application.

A new membership policy will be inaugurated. Certificates will be issued to members in good standing.

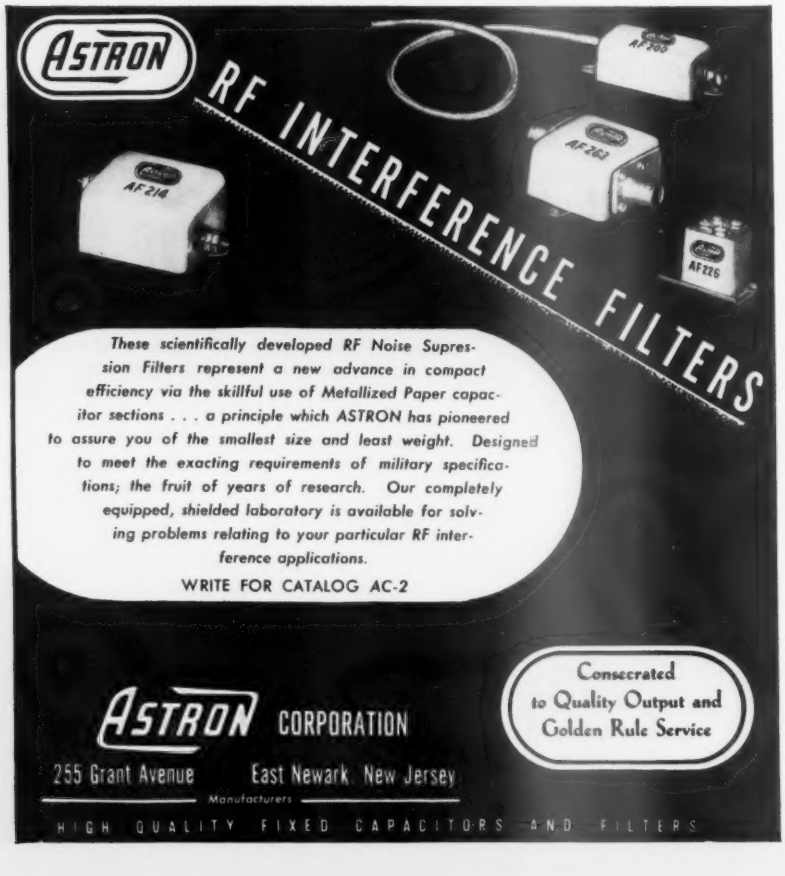
This page in the AERONAUTICAL ENGINEERING REVIEW is being set aside each month to record A.H.S. news items. We urge A.H.S. members to consider this space their own. All A.H.S. Regional Vice-Presidents and other members are invited to contribute interesting items of helicopter news. If enough of these reports are received from the United States and foreign countries, it is the plan of the A.H.S. to use the bulk of the material in forming this column in future issues. In this manner, all A.H.S. members will be kept informed of activities in the helicopter field throughout the world. *All contributions for future columns should be addressed to Bertram Kelley, President, American Helicopter Society, Bell Aircraft Corporation, Buffalo 23, N.Y.* All material must be on his desk no later than the last day of each month.

HARRY A. HABERER
Publicity Chairman, A.H.S.

Notice to A.H.S. Members

Send all contributions for future columns to:

Bertram Kelley
President, A.H.S.
Bell Aircraft Corp.
Buffalo 23, N.Y.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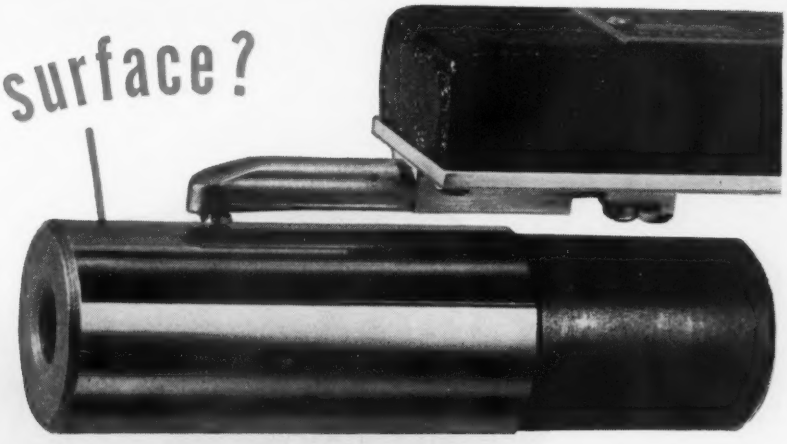

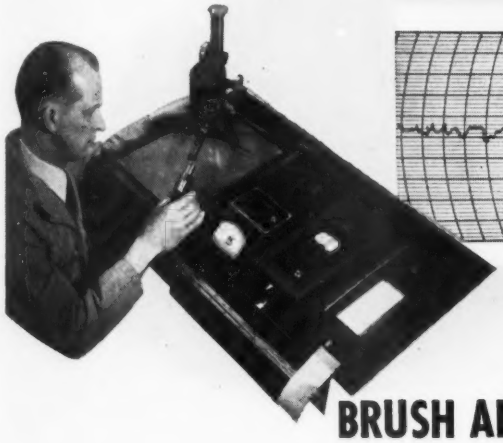

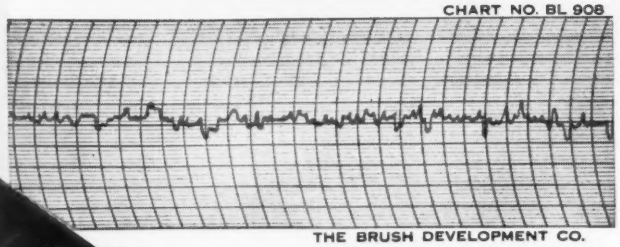

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Corporate Member News

(*Continued from page 44*)

tory has been prepared for free distribution. For a copy, write to Alcoa at 680 Gulf Building, Pittsburgh 19.

• **American Airlines System** . . . For operating 2,019,384,000 passenger-miles with a perfect record of no passenger or crew fatality between November 29, 1949, and the end of 1950, American was given the 1950 aviation safety award in the 2,000,000,000-mile category by the National Safety Council. American was the first air line to complete 4,000,000,000 perfect-record miles, having received that award about a year ago . . . A flight-training school, designed primarily for those pilots who do not yet have instrument ratings, has been established at Meacham Field, Fort Worth. New employee students will receive both instrument rating and Convair first-officer ground training concurrently. This new school supplements that at La Guardia Field . . . Walter H. Johnson, Jr., who has been Regional Vice-President—Eastern, was recently elected Secretary and Assistant to the President. C. W. Jacob, who was formerly Vice-President, Secretary, and Assistant to the President, remains on as Vice-President. Theodore P. Gould, formerly Director of Passenger Sales, succeeds Mr. Johnson as Vice-President for the Eastern Region.

• **American Helicopter Company, Inc.** . . . In a recent design competition for a collapsible, lightweight, jet-propelled helicopter, American Helicopter came out a winner. The helicopter, a single-place job, is capable of being loaded aboard an Army jeep in its collapsed state and of being assembled with facility in the field. It will operate on standard fuel used by the Army ground vehicles.

• **American Phenolic Corporation** . . . William H. Rous, formerly Sales Manager for American Phenolic, was elected Vice-President of the firm.

• **Bendix Aviation Corporation** . . . A 40-page booklet, *Bendix Aviation Corporation and Your Business*, recently issued, lists the hundreds of different products supplied by the corporation's 15 plants to all phases of American industry. It also contains detailed descriptions and illustrations of principal Bendix products and services as well as information covering the manufacturing facilities of the various divisions and subsidiaries.

• **Bendix Radio Division, Bendix Aviation Corporation** . . . The Bendix School for Electronics at Pimlico Airport, near Baltimore, was officially opened on May 17 in ceremonies attended by U.S.A.F. officials and executives of Bendix Radio, sponsors of the new training unit. This industry-sponsored school is operating on two "shifts" daily with a faculty of ten Bendix and two U.S.A.F. instructors and will train essentially Air Force personnel in the maintenance of military electronics equipment. For the Air Force, this 8-week course represents the final phase of training in electronic equipment. Additional courses now planned will double the activity in the near future.

A NEW ENGINE EQUALS NEW TESTS

Consolidated Vultee Aircraft Corporation's delta-wing XF-92A interceptor has undergone a new series of tests by U.S.A.F. and N.A.C.A. test pilots. Formerly equipped with the Allison J-33-A-23 turbojet with which the research interceptor flew 80 flights at speeds up to the transonic range, the XF-92A is now powered with the Allison J-33-A-29 turbojet engine with afterburner. This new engine, which develops considerably more thrust than the earlier model, is expected to provide substantially greater performance at high altitudes. The XF-92A was originally designated the Convair Model 7002.

A STUDY OF MOVABLE WINGS

Bell Aircraft Corporation's jet-propelled X-5 is the first aircraft to feature wings whose degree of sweepback may be varied in flight; a built-in mechanism compensates simultaneously for the resulting shift of the center of gravity. In this picture the wings have been moved to a rearward position, permitting greater speeds at high altitudes. The wings can be moved forward for best performance in take-offs, early climbs, and landings. The ship's specifications are: length, 33 ft. 4 in.; height, 12 ft.; weight, 10,000 lbs.; and wing span, 32 ft. 9 in. The X-5 will be used as a flying laboratory by the N.A.C.A. to investigate aerodynamic effects of changing the degree of wing sweepback during flight.

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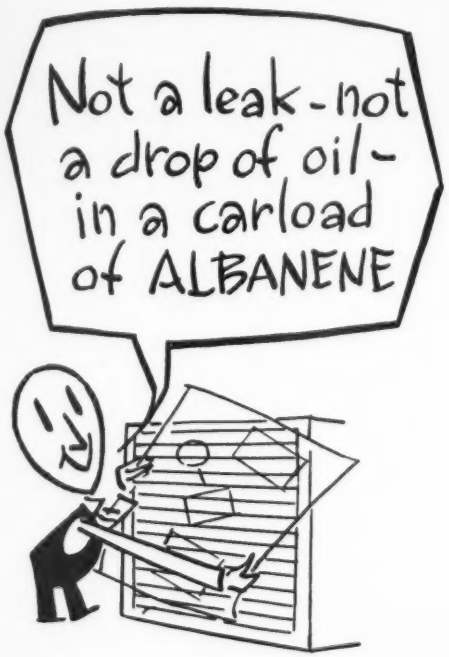

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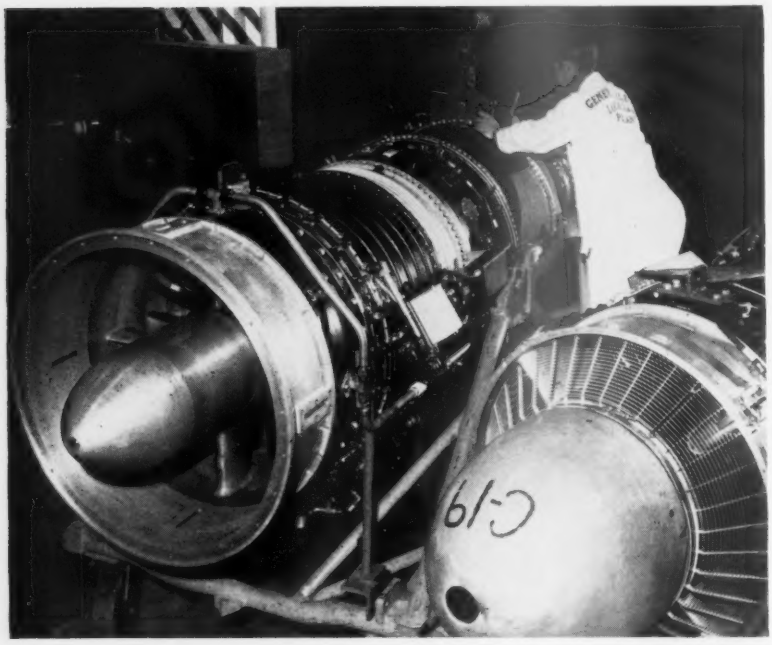

THE FIRST OF THE "ADVANCED J-47" SERIES

General Electric Company's recently introduced J-47-GE-21 (left) is said to have a far greater output than the present J-47 engine (right), although it is of the same frame size. The basic engine of the "21" measures 36.75 in. in diameter and 146 in. in length. Some of the engine accessories, housed in the nose in current production engines, have been placed underneath to provide a greater air inlet area to the compressor. With modification of accessory mountings and other minor changes, the "21" becomes the J-47-GE-29. The addition of an afterburner forms the J-47-GE-31. The "21" incorporates anti-icing features and high-altitude starting characteristics; it may be equipped for either water/alcohol injection or afterburning.

• **Boeing Airplane Company** . . . Orders for nine electronic computers, designed by Boeing's Physical Research Unit to solve dynamic problems in the company's own laboratories, have been received from Bell Aircraft Corporation; North American Aviation, Inc.; Lear, Incorporated; Lockheed Aircraft Corporation; and Johns Hopkins' Applied Physics Laboratory. Lockheed and Johns Hopkins each ordered three.

• **Brown Instruments Division, Minneapolis-Honeywell Regulator Company** . . . A new electronic high-speed pen recorder for measuring rapidly changing variables experienced in laboratory and test applications has been developed. The new device is said to provide accurate recording in rocket-engine testing where thrust of the engine is measured with a strain gage and to be applicable for analyzing fuel efficiencies and engine designs as well as for spectrographic and other analyses where relatively high scanning rates and narrow increments of change are encountered in a measured variable. It is also useful for determining instantaneous rates of flow as in jet-engine development. This new model records full-scale signals that vary as rapidly as 20 cycles per min. and those with peak-to-peak amplitude of 10 per cent of scale which vary as rapidly as 3 cycles per second . . . An intensified program for meeting increasing defense requirements has been established. This program includes coordinating and expediting of engineering, production, and delivery of highly sensitive industrial instruments.

• **Canadair, Ltd.** . . . Vice-Adm. Earl W. Mills, U.S.N. (Ret.), and George W. Codrington have been elected to the Board of Directors. Admiral Mills, who was formerly Chief of the Navy's Bureau of Ships, is President and a Director of Foster Wheeler Corporation and a member of the Board of Directors of several other firms. Mr. Codrington is a Vice-President of General Motors Corporation and General Manager of G.M.'s Cleveland Diesel Engine Division. He is also a Director of several other firms.

• **Consolidated Vultee Aircraft Corporation** . . . On May 25, an RB-36 completed nearly 1,500 hours of rugged tests in the air. These tests had been begun about 13 months previously to ensure that the basic design was able to endure a long and hazardous service life. The 55 test missions that were completed in that overall test period varied in length from 2 hours to 2 days . . . A manual joggle machine, devised to eliminate much of the expensive tooling, has been put into operation at the Fort Worth Division. Designed by Convair engineers, the machine has been put into mass production by Intercontinental Manufacturing Company, Inc. This particular machine is said to be peculiarly suited to aircraft manufacturing, because it can turn out compound joggles . . . The San Diego Division is receiving approximately $1,000,000 worth of new machine tools and equipment . . . The modernization of the last of 22 "Model A" B-36's has been completed for delivery to the Air Force as an RB-36E reconnaissance airplane.

• **Curtiss-Wright Corporation** . . . Flight simulators for the B-36, B-50-D, C-124, and C-97 are to be constructed for the training of U.S.A.F. pilots, under the terms of an Air Force contract . . . The entire Electronics Division was scheduled to move during the early part of July into the former Columbia Protektosite Company plant, Carlstadt, N.J., recently purchased by Curtiss-Wright.

• **Curtiss-Wright Corporation, Propeller Division** . . . A new-type propeller, a three-bladed job that swings through an 18-ft. arc, has been developed for use on submarine-hunting blimps. It permits the blimps to back up and hover as well as progress forward. The first of these new hollow-steel air screws has been installed by the Navy on the Goodyear ZPN, which will be powered by two 800-hp. Wright Cyclones.

• **Douglas Aircraft Company, Inc.** . . . Last spring, a C-124 Globemaster II took off with the heaviest load ever carried up to that time by a production transport airplane. Taking off with a gross weight of 210,000 lbs., the airplane was flown a distance of 1,000 miles, unloaded, and flown back to its base without refueling. This record-breaking performance, which exceeded design take-off gross weight by 35,000 lbs., was made under standard aircraft-characteristics conditions to determine maximum load-carrying capabilities of the largest cargo and troop carrier operated by the Air Force . . . A factory building at Bell, Calif., was recently purchased and will be used for the manufacture of honeycomb sandwich development. The plant was formerly occupied by Southern California Homes, Inc.

• **Eastern Air Lines, Inc.** . . . A 1950 aviation safety award for completing 1950 with a perfect record of no passenger or crew fatality was presented to Eastern by the National Safety Council. Eastern had completed 1,431,600,000 perfect-record miles by the end of 1950 . . . Joseph H. Brock, who has been Director of Industrial and Personnel Relations since 1947, was elected Vice-President of Industrial and Personnel Relations. He will remain in Miami.

• **Esso Standard Oil Company** . . . Two new flat-topped aircraft refuelers have been put into service at La Guardia for United Air Lines. Each of these airport tenders has a four-compartmented capacity of 5,000 gals. and a maximum pumping rate of 400 gals. per min. Two 50-ft. hoses that can be operated simultaneously are stretched out on each of the vehicles' flat grilled deck top. Operators can work from these decks via a short ladder to the wing of the airplane being refueled. Two more of these units are planned for operation in New England.

• **Elastic Stop Nut Corporation of America** . . . A high-temperature vibration testing rig has been set up at the Union, N.J., plant for the purpose of testing critical vibration requirements of stop

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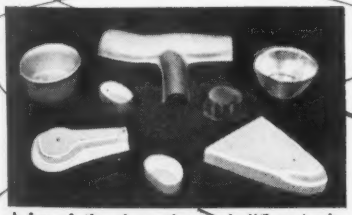

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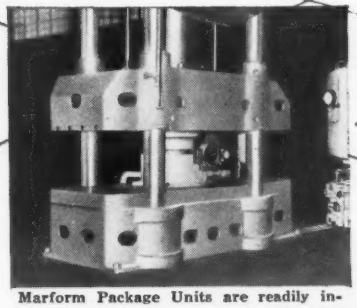

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NORTH AMERICAN'S 45,000TH

Shown before the 45,000th military airplane to be designed and produced by North American Aviation, Inc., as it was being delivered to the United States Air Force on June 7 are: (left to right) Lt. Col. R. M. Creech, U.S.A.F. Resident Representative at North American; J. S. Smithson, North American's Factory Manager; J. H. ("Dutch") Kindelberger, I.A.S. Fellow, Founder Member, and Past-President and North American's Chairman of the Board and Chief Executive Officer; and Brig. Gen. D. F. Stace, Chief, Los Angeles Procurement Office, U.S.A.F. General Stace accepted the aircraft pictured on behalf of the U.S. Air Force. The plane, on whose side Mr. Kindelberger indicates that there "are more to come," is a production model of the F-86E Sabre jet. An earlier model of the Sabre, the F-86A, holds the official world's speed record of 670.98 m.p.h.

nuts, especially those used in aircraft manufacture. Because the stop nuts must be designed to operate at extremes of temperature, the testing rig is so constructed that it can provide ambient temperatures ranging from subarctic to 2,000°F. This unit, which can simulate conditions more severe than the normal vibration encountered in piston and jet-engine operation, can be used to determine whether or not self-locking nuts under development can ultimately pass existing or proposed Army-Navy test specifications.

• **Fairchild Aircraft Division, Fairchild Engine and Airplane Corporation** . . . Phase II flight testing of the XC-120 Pack Plane was completed in May at Wright-Patterson Air Force Base, Ohio. Further evaluation of the XC-120 was scheduled to take place at the Air Proving Ground, Eglin Air Force Base, Fla. . . . A close liaison between tool designers of Topflight Tool Company, Inc., and inspection engineering personnel of Fairchild has resulted in a new type of completely automatic machine for testing and certifying the hardness of sheet-metal parts. The current-model machine's output of accurately tested and stamped small parts represents a saving of 400 man-hours per week. Fairchild is now using four of the current-model machines on C-119 Flying Boxcar production.

• **Fairchild Guided Missiles Division, Fairchild Engine and Airplane Corporation** . . . Construction of a new one-story brick and steel structure began June 5 on a 32-acre tract of land in Wyandanch, L.I., N.Y. This $1,750,000 plant, which is expected to be completed late this year, will be devoted to the development and production of guided missiles. The building is so constructed that it may readily be expanded, and the site is suitable for construction of up to 1,000,000 sq.ft. of factory space.

• **General Electric Company** . . . Six manufacturing affiliates of G-E became departments of the parent company on June 30. These include Carboloy Company, Inc., of Detroit; General Electric X-Ray Corporation, of Milwaukee; Locke, Inc., of Baltimore; Telechron, Inc., of Ashland, Mass.; Monowatt, Inc., of Providence, R. I.; and The Trumbull Electric Manufacturing Company, of Plainville, Conn. As G-E departments, these six former subsidiaries are operating under their former management, and their products are being marketed under their existing trade names . . . Bulletins GEA-4866A and GEA-5628 are available. The first one, GEA-4866A, is entitled *G-E Transformers for Aircraft* and deals with ballasts for fluorescent lighting for aircraft, general purpose transformers, ignition transformers, etc. The second one, GEA-5628, touches upon G-E's 28-volt generator control systems for multiengined aircraft.

• **The B. F. Goodrich Company** . . . New bullet-sealing fuel cells for jet fighters and bombers weigh 33 per cent less than their World War II predecessors. This weight saving may represent hundreds of pounds.

• **Jack & Heintz Precision Industries, Inc.** . . . At the annual meeting of the stockholders of the company held last May, a change of corporate title from "Jack & Heintz Precision Industries, Inc." to "Jack & Heintz, Inc." was approved. The effective date for this change of corporate title was scheduled for the latter part of last month.

• **Walter Kidde & Company, Inc.** . . . World War II arrangements for the manufacture of Kidde automatic gun-chargers for the U.S. Government by Remington Rand, Inc., has been renewed. The one now to be manufactured is an improved version of the Model-K Kidde gun-charger formerly produced by Remington and is known as the B-1. The new charger, driven by compressed air, is designed for both bomber and combat airplanes.

• **Meletron Corporation** . . . Frank Rousseau of Rousseau Engineering and Sales, Montreal Airport, Dorval, Ontario, Canada, has been appointed Meletron Sales Representative for the provinces of Quebec and Ontario, Canada.

• **North American Aviation, Inc.** . . . The cockpit of the F-86-D will be duplicated in flight simulators for Air Force pilot training, according to the terms of a U.S.A.F. contract.

• **North American Aviation, Inc., and Goodyear Aircraft Corporation of The Goodyear Tire & Rubber Company** . . . A subcontract for the manufacture of wing and empennage assemblies of North American's T-28 trainer was awarded to Goodyear. The work will be done at Phoenix, Ariz., Goodyear plant at Litchfield Park. The contract runs until the end of 1952.

• **Pratt & Whitney Aircraft Division, United Aircraft Corporation** . . . The axial-flow J-57 turbojet engine, said to be the most powerful now flying in the United States, was carried aloft recently on a test flight by a specially rigged B-50 Superfortress. The J-57 Turbo-Wasp, developed by Pratt & Whitney for the Air Force, is much more powerful than P. & W.'s J-48 Turbo-Wasp. The J-48, which is rated at 6,250 lbs. static thrust plus afterburner power, is believed to be the most powerful U.S. turbojet engine actually in production and being delivered to the Navy and Air Force . . . A recently developed method of storing sheet-metal stock as "books" in a "library" rather than flat is said to result in a 90 per cent saving in the man-hours required for handling the vast quantities of sheet-metal stock used in Pratt & Whitney's production of turbojet and turboprop engines . . . Instruction on a three-shift, 'round-the-clock basis began on May 17 at the new machine training school in Hartford. The object is to provide a large number of production workers.

• **A. V. Roe Canada Limited** . . . A fault analyzer for indicating and locating faults in the a.c. electrical system of Avro's Jetliner has been developed. This

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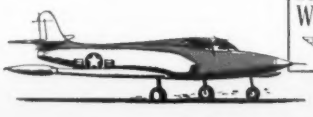

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analyzer incorporates a bank of warning lights mounted on the control panel to indicate the type of electrical fault involved and its location . . . A vaporizing system that provides an even distribution of fuel injected into a combustion chamber has been developed. This vaporizer incorporates a common annular nozzle; the downstream end of each vaporizer tube is led into this nozzle to give better mixing . . . The CF-100 fighter, powered by two Orenda engines, made its first flight on June 20.

• **Simmonds Aerocessories, Inc.** . . . Matthias Plum of the legal firm of Breed, Abbott & Morgan has been elected to the Board of Directors.

• **Standard Oil Company (Indiana)** . . . Frank O. Prior was elected Executive Vice-President. Mr. Prior, who is also a Director and member of the Executive Committee of the company, was formerly their Vice-President in Charge of Production.

• **Tinnerman Products, Inc.** . . . The production of Flat Type Aircraft SPEED NUTS that save as many as 3 man-hours for every 1,000 fastenings has been announced. These self-locking fasteners are interchangeable with AN 364 and AN 365 nuts on screw-driven nonstructural applications. The Aircraft Flat Type SPEED NUTS are listed in NAS 446 standards for 4, 6, 8, and 10B (Z) tapping screws. The 10B type takes an AN 530 screw with a tapered lead and coarse threads for quicker starting and faster driving . . . Publication of a new aircraft designers' catalog of SPEED NUT fasteners was announced. This new Aircraft Parts Catalog No. 500 lists all the aircraft fasteners manufactured under Mil-N-3337 specifications. In addition to other information, the booklet gives detailed specifications for fasteners as well as their possible applications . . . The Pacific coast district office has been moved to 353½ North LaBrea Avenue, Los Angeles.

• **Trans World Airlines, Inc.** . . . The National Safety Council has named T.W.A. as one of the winners of the 1950 aviation safety awards in the 1,000,000,000-mile category or multiples of that amount without a passenger or crew fatality. Specifically, T.W.A. operated 4,420,434,000 passenger-miles with a perfect record between March 11, 1947, and August 31, 1950. T.W.A. is the second air line in history to pass the 4,000,000,000-mile mark . . . Two new sections have been added to the Engineering and Maintenance Department. These additions are to be known as Technical Services and Flight Test and Inspection. They will be located at the T.W.A. Overhaul Base in Kansas City . . . John L. Weller has been named Assistant Vice-President . . . Ronald Duckworth has been named an Assistant Treasurer.

• **United Air Lines, Inc.** . . . For operating during 1950 without a passenger or crew fatality, United was given a 1950 aviation safety award by the National Safety Council. United, which about a year ago won a 2,000,000,000-mile award for operating that amount without passenger or crew fatality, had flown 3,620,400,000

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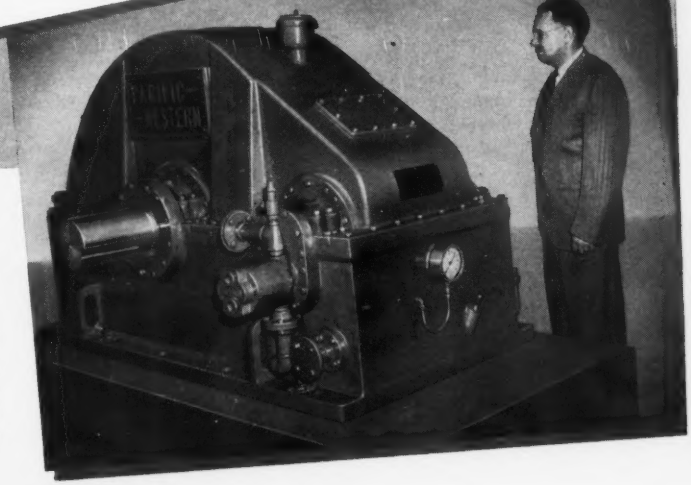

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miles with perfect safety by the end of 1950 . . . Research on a potential method for fog and stratus cloud dispersal will be launched early this fall. Under the direction of ex-Navy fliers Harvey M. Brandau and Eugene K. Kooser, a specially equipped United DC-3 airplane will diffuse chemicals that its compounders (Brandau and Kooser) call "Formula X." The areas in which the chemicals will be diffused are to be selected by United officials. These experiments should determine if the Brandau-Kooser method has practical application to scheduled air-line operations . . . A high-intensity rotating red light mounted on the vertical stabilizer is now undergoing service tests on a United DC-6 Mainliner 300. A second development, blueprinted for early testing, should double the flashing rate of wing-tip and fuselage lights.

• **Westinghouse Electric Corporation** . . . A new plant containing 1,900,000 sq.ft. of floor space is being built on a 350-acre site 3 miles west of Columbus, Ohio. Construction of the one-story-type factory building will take approximately 18 months, and, when completed, it will be used for the production of jet-engine components. After defense requirements are met, it will be converted to the manufacture of electric home appliances. The Columbus plant will be operated by the Westinghouse Electric Appliance Division . . . The new Union City, Ind., plant now under construction will be geared to produce 75,000 electric motors a month. The plant will be located on 35 acres of ground and will contain 140,000 sq.ft. of floor space. Ralph E. Davis will be the Manager . . . T. I. Phillips, a Westinghouse Vice-President, who was formerly in charge of the East Pittsburgh Division, has been assigned to the industrial products staff to help plan and carry out the company's industrial expansion program.

I.A.S. Sections

Baltimore Section

M. F. Taylor, *Secretary*

The thirtieth meeting of the Baltimore Section was held on April 26 at the Engineers Club of Baltimore.

The Chairman, Captain Higgins, called the meeting to order at approximately 8:45 p.m. The Secretary gave a brief report on the Inspection Trip to the U.S. Naval Experimental Station on March 27. In the absence of the Treasurer, the Secretary reported the current treasury balance as of April 26 was $44.68. There was no old business. Under new business, the Chairman announced that nominations were in order for the 1951–1952 Section Officers and called upon G. L. Bryan, Jr., Chairman of the Nominating Committee. Mr Bryan and his committee proposed certain nominations. No additional nominations were offered from the floor. A motion was duly made, seconded, and approved by voice vote that the nominations be closed. The Program Committee Chairman reported that the Section Annual Dinner would have as a guest speaker, William A. M. Burden, Special Assistant to the Secretary of the Air Force. The Chairman then announced that the scheduled speaker of the evening, William G. Purdy, was ill and that W. W. Bender, Chief, Electrical-Mechanical Department, The Glenn L. Martin Company, would substitute for Mr. Purdy. Mr. Bender lectured on the "Design Characteristics of the Viking Rocket."

The Viking Rocket, a development stemming from experiments conducted in this country with German V-2 Rockets after World War II, is a single-stage rocket designed as a high-altitude research vehicle for use in exploring the characteristics of the upper atmosphere. The Glenn L. Martin Company is currently under contract with the Naval Research Laboratory, Rocket Sonde Division, for the development, design, fabrication, instrumentation, and testing of the Viking.

Thrust for propelling the rocket is provided by a rocket motor developed and manufactured by Reaction Motors, Inc., and operates on a liquid-oxygen and a liquid-alcohol propellent.

The Viking is designed to operate as a stable platform while ascending to an altitude exceeding 100 miles, according to the speaker. The rocket is launched with an initial acceleration of 2-g units. During the 75 sec. of powered flight, the bird passes through the transonic range and attains a speed exceeding Mach 6 at the end of burning. Just prior to this moment, the rocket, now weighing a quarter of the launching gross weight, is accelerating in excess of 5-g units at an altitude approaching 140,000 ft. Maximum drag occurs in passing through the transonic range, with consequent dip in the increase of acceleration, followed shortly by a maximum dynamic pressure condition of 1,200 lbs. per sq.ft. "Peak time" occurs within 5 min. of launching.

Mr. Bender indicated some of the problems involved in designing the rocket to operate over the extreme range of physical conditions mentioned above: (1) stability and control problems arising from center of gravity travel with release of burned fuel and the low dynamic pressures prevailing at launching and again over the interval from near the end of burning until reaching maximum altitude; (2) fuel-injection control and fuel-tank static head loading problems caused by the wide acceleration range; and (3) transient thermal problems attending the dynamic pressure peak.

The speaker indicated the nature of the solution to such problems, some of which had to be tackled entirely without benefit of previous experience. This was followed by a résumé of the six flights made to date, one of which achieved an American-class altitude record (106.7 miles). The talk was followed by a color film of the rocket in various stages of construction, installation, transportation, handling, erection, testing, launching, and flight. The meeting ended after a short discussion period.

Boston Section

L. J. Nuttall, *Secretary*

Robert L. Lichten, Project Engineer, Bell Aircraft Corporation, addressed the Boston Section at the May 16 meeting at Harvard University. The subject of the meeting was "Convertible Aircraft Development," in which much interest has been shown among the members of the section.

Mr. Lichten pointed out the need for an aircraft that could combine the ability of the helicopter to take off vertically and hover with the ability of the airplane to fly at high speed over long distances. The requirements of such an aircraft to justify the development cost would be that both the low- and high-speed characteristics be as good as the performance of comparable helicopters and airplanes in their respective flight regimes. He followed this with a brief comparison of the various types of convertiplanes—those with the fuselage horizontal throughout the entire flight range and those with fuselage vertical at take-off and horizontal at high-speed flight, those with separate rotors for lift at low-speed flight and propulsion in high-speed flight and those with rotors whose axes can be tilted for either vertical lift or horizontal propulsion.

The Bell Aircraft Corporation was one of the winners in the recently conducted Air Force convertible aircraft competition with an aircraft whose fuselage remained horizontal throughout the flight range and which used the same rotor for lift and propulsion.

The remainder of the talk was concerned with the design and operational problems of this type of aircraft. One of the main problems was the efficiency of helicopter rotors when used as propellers. Mr. Lichten presented comparison data to show that by changing the rotor speed reasonable efficiencies can be obtained.

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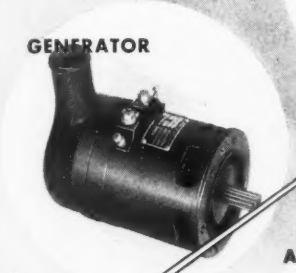

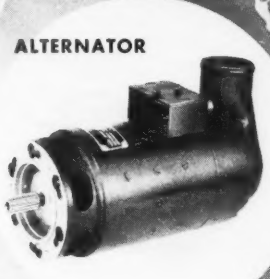

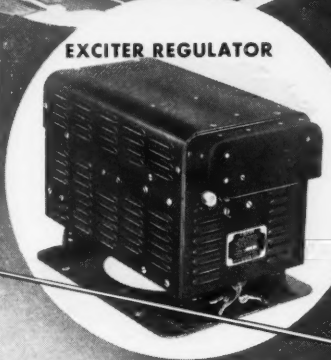

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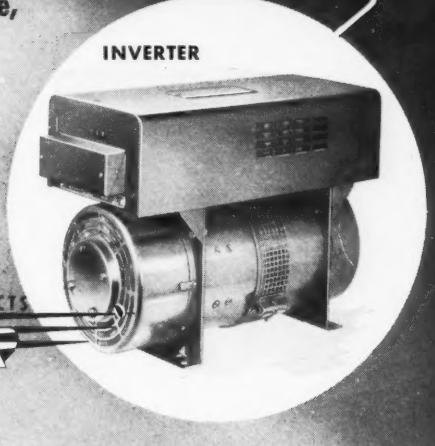

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The talk was followed by a short film on "Convertible Aircraft Model Flight Demonstration."

Buffalo Section

Hans Weichsel, Jr., *Secretary*

Joseph Mashman, world-renowned helicopter engineer and pilot, addressed a joint meeting of the I.A.S. Buffalo Section and American Helicopter Society on May 9 at the Westbrook Hotel, Buffalo.

One hundred and twenty-five persons heard Mr. Mashman tell of his recent experiences in Korea with helicopters. He illustrated his excellent talk with numerous colored slides and movies. Mr. Mashman told an amazing story of how a small group of helicopter pilots and a handful of personnel are doing such a tremendous job of evacuating the wounded, military liaison observation, and cargo carrying in the combat zone of Korea. Considering the inadequate equipment, helicopter maintenance in Korea is phenomenal. Mr. Mashman mentioned that pilots with less than 100 hours of helicopter flight time are flying missions that commercial pilots with several hundred hours of flight time would not dare to attempt. Mr. Mashman told of his experience of flying under mortar and artillery fire in front-line positions only to find a general there who was flying his helicopter under similar combat conditions. Landings were made on razor-back mountains so sharp that the pilot had to balance the landing skids on the ledge while ground personnel loaded the wounded. It was stated that the Bell H-13D and HTL-4 were predominant in these front-line positions.

Chicago Section

Alfred F. Stott, *Secretary*

The Annual Meeting of the Chicago Section was held on May 11 at the Naval Air Station, Glenview, Illinois. This was the third meeting held at this location, and, as usual, an excellent time was had. The program started with a tour of the facilities. Capt. Wallace Mechling, U.S.N., who was responsible for all arrangements for the meeting, conducted one group on the tour, while Jack Witten was in charge of the second group. Forty-four people took the tour.

Following this, a social period and dinner were held in the Beachcombers Room of the Officers Club. Eighty-eight persons attended and had their choice of a lobster tail or steak dinner. At 9:00 p.m., Section Chairman K. L. Burroughs called the business meeting to order. He introduced Capt. R. M. Oliver, U.S.N., Commanding Officer of the Glenview N.A.S. Captain Oliver welcomed the members and guests; Mrs. Oliver was also introduced, as were the remainder of the officers of the Chicago Section and their wives.

The election of officers for the year 1951–1952 was held with the following results: Chairman, Robert H. Wendt; Vice-Chairman, Harvard L. Hull; Secretary, Alfred F. Stott; and Treasurer, Charles L. Bonnett. The following were elected to the advisory board: K. L. Borroughs, H. V. Hawkins, R. O. Britten, Capt. Wallace Mechling, J. F. Witten, R. S. Hartenberg, O. J. Engle, and J. C. Battaglia. Lee W. Sims was chosen as representative to the Nominating Committee for Area Councilors.

The retiring Chairman, K. L. Burroughs, thanked the officers and members for their splendid cooperation during the year and told of the pleasure he derived from being Chairman. He introduced the new Chairman, Robert Wendt, who expressed his appreciation for the honor conferred on him and spoke briefly of coming events. The meeting was adjourned at 10:15 p.m.

Detroit Section

Henry H. Kerr, *Chairman*

A new and practical system of simplified aircraft controls developed by Dr. Frederick W. Ross, one of the Detroit Section's own members, was described as the highlight of an unusual meeting of the Detroit Section on May 10.

The meeting, attended by more than 200 members and guests, was held in the hangar of the Aero Mechanics School, Detroit City Airport, where an airplane with the controls installed was on display.

With the cooperation of George E. Tabraham and Robert Dale of the Aero Mechanics School; Ken Smith, Aeronautical Department Head, University of Detroit; and Henry H. Kerr, I.A.S. Detroit Section Chairman, the hangar facilities were rearranged to accommodate the large number of persons desiring to attend the meeting.

Dr. Ross, Professor of Aeronautical Engineering, University of Detroit, was preceded on the speaker's platform by Major Gen. H. H. Johnson, Commanding Officer, 10th Air Force, Selfridge Air Force Base, and the Very Rev. Celestin J. Steiner, S.J., President, University of Detroit.

As the principal speaker of the evening, Dr. Ross presented the new system and showed its relation to the historical development of aircraft control. The high points of 6 years of theoretical and experimental analysis, resulting in the development of the new control system, formed the basis of Dr. Ross' lecture.

In contrast to other simplified control systems devised previously, it was pointed out that with the Ross method there is no sacrifice of control. There is no restriction whatsoever on control-surface travels or on maneuvers. The simplification obtained with the new

Principals at Detroit Meeting: *Shown at the May 10 meeting of the Detroit Section from left to right are: Henry H. Kerr, Chairman, Detroit Section; Dr. Frederick W. Ross, Principal Speaker; the Very Rev. Celestin J. Steiner, S.J., President, University of Detroit; and Major Gen. H. H. Johnson, Commanding Officer, 10th Air Force, Selfridge Air Force Base.*

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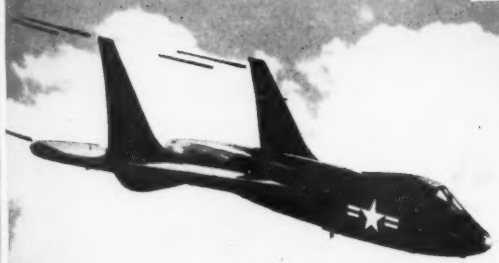

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controls aids in training the new pilot and makes flying much easier for the experienced flier. The beginner can fly the airplane much in the manner in which he drives his car. He need not learn several new, confusing balancing and force techniques, because the airplane reacts directly with the motion of the control levers.

Dr. Ross went on to say that, although there are only two levers—the conventional wheel or stick for ailerons and elevators and a "trim" stick for rudder—the pilot has full but simple and easy control in every conceivable maneuver of an airplane. Stalls, spins, cross-wind landings, full sideslips, snap rolls, and slow rolls are all accomplished in the Ross method with combinations of only two straightforward operations of the control levers by the pilot. This is in direct contrast to the six or ten manipulations required of pilots maneuvering an aircraft with conventional control systems. Technically, the new control system is classified not as a two-control type but rather as a simplified three-control type.

The new system is said by Dr. Ross to be easily adaptable to any airplane regardless of its size or speed. Installation, he says, is simple, and the mechanism, consisting of eight ordinary rods tied into, or tapped off, the control cables, needs little maintenance because of its ruggedness. Installed at present in Dr. Ross' Aeronca, the gear has been in service for more than 300 flights under varying weather conditions over the experimental period of 2 years.

Theoretical analysis that led to the assembling of the new controls was approached by research on the steering requirements of an air-borne vehicle in terms of (1) basic forces, moments, and energies required for steering and (2) basic characteristics of aerodynamic lifting devices and roll and yaw controls. Dr. Ross found that the ratio of aileron deflection to rudder deflection could be taken and used in the interests of simplifying the required mathematics. The resultant findings were supported, Dr. Ross said, by flight-test data, and he was able to produce the necessary mechanical assembly from that research and flight tests. Now past the experimental listing, the controls are acceptable for commercial use.

Veteran pilots are said to report a distinct reduction of piloting fatigue and an improvement in precision of flight control while using the Ross system of controls.

This meeting at which the new controls were described was attended by C.A.A. Representatives W. F. Norton and J. W. Thomason of the Third District (Chicago). Also among the guests were Lt. Col. George Jones and Major John Baleski of the 56th Fighter Group,

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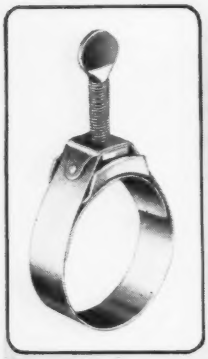

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U.S.A.F., Selfridge Air Force Base, as well as Lt. Carl Foster, U.S.N., of Grosse Ile Naval Air Station. James W. Kinnucan, of Continental Motors Corporation, and many other persons, prominent in aviation, were on hand for the meeting.

Coffee and doughnuts, provided by the General Aircraft and Supply Company, and an inspection of the facilities of the Aero Mechanics School rounded out this unusual meeting, which climaxed the present series of the Detroit Section's activities.

Dayton Section

Major W. A. Barden, *Secretary*

The Dayton Section held its final meeting of the season at the Biltmore Hotel on May 24. Approximately 80 members and guests were present to hear Robert E. Hage, Design and Sales Engineer, Boeing Airplane Company, speak on the subject, "Aircraft of the Future."

Mr. Hage presented performance data for aircraft of various sizes, with different types of power plants, and for a number of conditions of range, speed, and altitude. Then he developed a generalized equation from which a selection could be made of the best type of aircraft for air-line operation. He concluded that turbojet-propelled aircraft having a range of 1,000 miles, operating at 25,000–30,000-ft. altitude, and cruising at 500–600 m.p.h. offered the air lines the best return on their investment.

Mr. Hage's talk was supplemented by the showing of a movie called *Double Deck Clipper*. This movie was produced by Pan American World Airways and dealt principally with the Boeing Stratocruiser.

The meeting ended with an interesting discussion period during which Mr. Hage answered a number of questions about his conclusions.

An interesting feature of the meeting was the presentation of I.A.S. keys to Col. A. A. Arnhym, U.S.A.F., and A. F. Arcier, the past chairmen of the Dayton Section since its reactivation.

▶ The results of the election of officers for 1951–1952 are as follows: Chairman, Lt. Col. Floyd J. Sweet; Vice-Chairman, Major William A. Barden; Secretary, Charles L. Hall; and Treasurer, Charles M. Mitchell. These men will actually assume their duties on July 1, although installation of officers will take place at the September meeting.

Hagerstown Section

Robert A. Darby, *Secretary*

The meeting of May 24 was held in the meeting room of the Moose Hall in Hagerstown with Robert D. Gilson, Section Chairman, presiding. The speaker of the evening was Vincent Thurn, Field Representative, Fairchild Aircraft Division of Fairchild Engine and Airplane Corporation, who was back at the Fairchild plant briefly after several months in Japan and Korea.

Mr. Thurn spoke at some length of the operation of C-119 airplanes between Japan and Korea in the present war, putting his talk in the form of a travelogue. Points brought out by Mr. Thurn of particular interest to the design engineers present were the extreme congestion of aircraft, trucks, and equipment at a Japanese base that occupies a mere toehold between the mountains and the ocean and the difficult take-off conditions. The main runway, invariably full of bad holes, is either a sea of mud or a ribbon of powdery dust over the steel matting. When dry, planes after the third or fourth in a routine group take-off are obliged to use instrument procedure. Operating under muddy conditions, the airplanes become virtually caked with mud on the under surfaces. Even the mechanism within the wheel wells does not escape this ubiquitous mud. The speaker had several reels of film that he had taken on the scene to illustrate his points.

Mr. Gilson announced that this would be the last meeting of the Hagerstown Section until fall, when the annual election of the new officers would be held.

Los Angeles Section

Milton A. Miner, *Secretary*

The highlight of the month of March was the talk by Major Charles E. Yeager, U.S.A.F., at a dinner meeting at the I.A.S. Los Angeles building on March 15. Major Yeager's topic was "Experiences in High-Speed Flight of Conventional and Delta Wing Aircraft." He reported that delta-wing-type jets that he has been flying recently will apparently not stall even at low speeds and high angle of attack but require a great deal of thrust to maintain this attitude.

The problem of high-altitude flying which concerns the pilot the most is that dealing with adequate oxygen even under emergency conditions. Above 50,000 ft., pressure breathing is necessary, and at least three approaches are being tried. These are (1) pressurized cockpits, (2) pressure suits, and (3) pressure breathing. A mechanical failure is so critical for the pilot that the addition of a semipressure suit is probably indicated.

Above 33,000 ft., 100 per cent oxygen is used; without oxygen, the average pilot will lose consciousness in 9 sec. and cannot live much beyond 15 sec. Thus, any explosive decompression requires a return to 33,000 ft. within a few seconds. The logical solution appears to be a partial pressure suit. Tests showed that at a pressure altitude of 100,000 ft., test pilots were comfortable. Many new aeromedical developments are promising for pilot comfort and safety at high altitudes.

New helmets and a thin nylon flying suit are two items that have recently been developed.

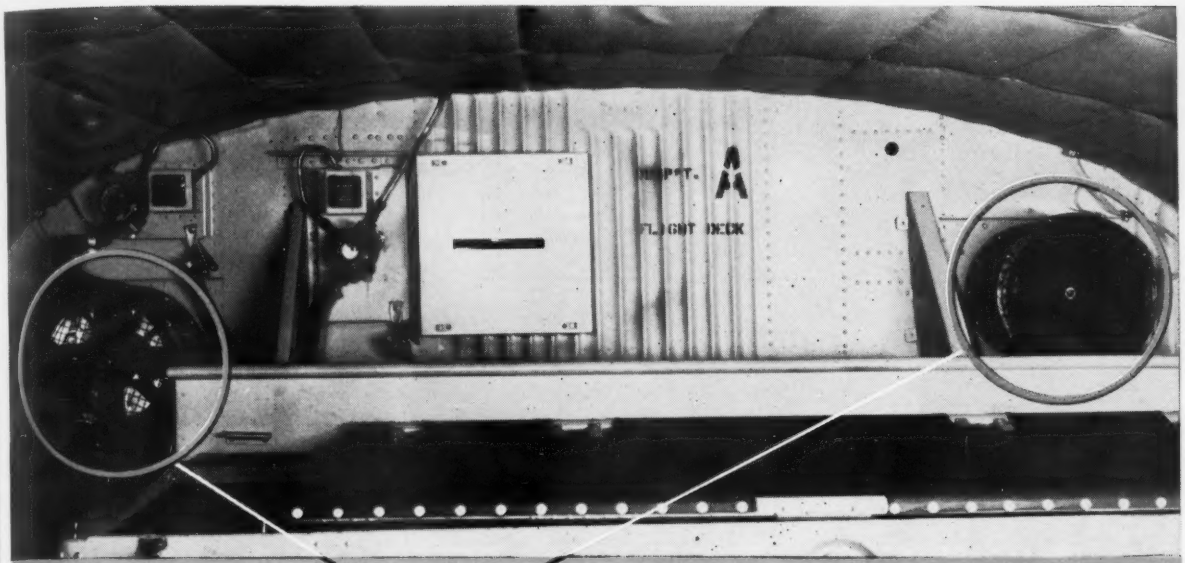
At altitudes possible at Mach Numbers of 1.5 and 3, problems arise which are unique to human experience. Lack of gravity results in failure of bodily organs to function properly. Major Yeager remarked that a maneuver developed to simulate lack of gravity was accomplished by holding an airplane capable of 450 m.p.h. or more in a push-over maintaining zero *g*'s. About 40-sec. duration at zero *g*'s is possible and the sensations resulting, such as the feeling of one's head swelling, are often nauseating to a pilot.

The problem of simulating gravity is not at all a simple one and will require considerable study.

Also, Major Yeager pointed out that flying at 1,500 m.p.h. brings up some pilot response situations that make flying a high-speed interceptor something more than a casual matter. At 1,800 m.p.h., the pilot must see another airplane at about 5,000 ft. in order to avoid a collision if the flight paths intersect.

Major Yeager concluded his talk by answering a number of questions from the audience about flying delta-wing craft and also about various aspects of high-speed flight.

In addition to Major Yeager's enjoyable and informative talk, two specialists meetings were held in March. The first on March 1 was on the subject of "Some Meteorological Problems Indicated for Jet Transport Operation at 40,000 Feet" and was presented by H. T. Harrison, Jr., Manager of Weather Service, United Air Lines. This was a repetition of an important paper from the recent Annual Meeting in New York. Mr. Harrison indicated that analysis of available upper-air data reveals that three weather factors that will most likely present flight-planning operating problems when jet transports are placed in service to cruise at 40,000 ft. are: (1) clear-air turbulence (2) high-wind components, and (3) extreme temperatures. Present methods of upper-air chart analysis should prove satisfactory in predicting temperature changes at all levels, but turbulence and winds will require the development of new analysis and forecasting methods in order to permit realistic forecasts to be made at the flight-planning stage. The Weather Bureau network of RAWINSONDE stations must be expanded to a point where wind observations at 40,000 ft. will equal the number of tem-



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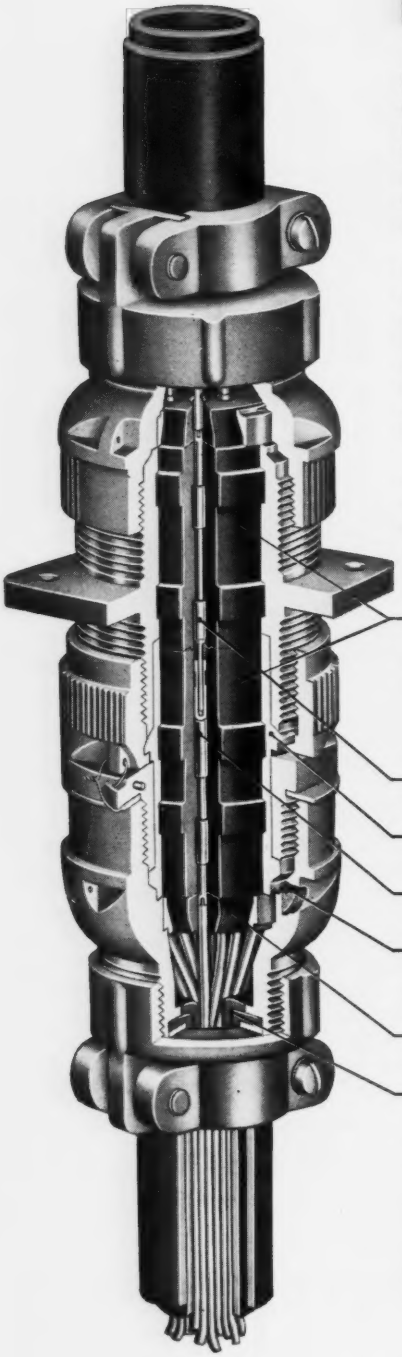


Here's another example of the meticulous care Cannon Electric uses in building connectors for highly specialized, tough jobs. This AN-"M" type connector is moisture-proof, vibration-proof and pressurized. Radio shielding is provided and every threaded part is drilled for safety wiring.

No corners are cut – nothing is overlooked to assure you outstanding performance. This connector is designed for aircraft use but there are more than 18,000 different Cannon Plugs made with the same care to serve the exacting needs of many industries. If you are looking for real value, regardless of the field you work in, your best bet is Cannon.

Engineering bulletins describing each of the many basic types of connectors are available. We will gladly send you any of these if you will simply describe your connector requirements.

Molded Polychloreprene inserts 75-80 shore hardness provide pressure-proofing of both pin and socket contacts. Have high dielectric strength under wide range of temperatures and at extreme altitudes. Mated fittings will not show more than 10 microamperes dielectric leakage and will not arc when subjected to 7500v dc at room temperature.

Pin Contacts machined from solid brass, silver-plated. Solder cup hand-tinned.

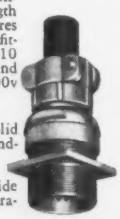
Machined ball-in-cone joints provide radio shielding and improve vibration resistance.

Socket contacts machined from solid copper alloy with new Cannon design, silver-plated.

Matching serrations in end bell and shell make practical wrench-tightening from one side of the installation without putting strain on contacts or wires.

Polychloreprene grommets make moisture-proof seal over soldered connections.

Concentric rubber bushings under pressure of cable clamp provide snug, moisture-proof wire entry. Eliminate usual strain on outer wires. Provision is made for grounding lug.



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Also, on March 22, a paper on the subject of "Expansion Phenomena in Shock Waves in Gases" was delivered by Dr. J. M. Burgers, Professor, Aero- and Hydrodynamics Laboratory, Technical Institute, Delft, Holland, 1950–1951. Dr. Burgers discussed the results of some recent studies in the dynamics of gases in nonuniform motion. The topics presented included (1) simple expansion waves in a gas, (2) Hugoniot relations for a shock wave, (3) shock wave propagating itself with decreasing velocity, and (4) the influence of a density gradient on the propagation of a shock wave.

▶ The activities for the month of April were highlighted on the 19th by a well-received address by the I.A.S. President, Rear Adm. L. B. Richardson, U.S.N. (Ret.). His subject was "Technical Progress and Air Power in the World Crisis."

J. H. "Dutch" Kindelberger, Chairman of the Board, North American Aviation, Inc., introduced Admiral Richardson with a number of amusing anecdotes.

Admiral Richardson presented arguments supporting the thesis that technical superiority is of vital importance to the nation in either a long or short period of international crisis, particularly the former. Qualitative superiority in the air is vital and must be maintained for our future security. The aircraft used in World War II were developed before the war. New weapons, other than aircraft, had a decisive effect on the outcome. Admiral Richardson felt that we should have been able to put turbine aircraft into use during the last war. Overall U.S. developments are abreast of anyone, but Russia's use of German scientists may put them ahead in some fields. The last war forced a slow-down of development in order to concentrate on production of items "frozen" in design. We must not make this mistake again, according to the speaker. Quality has been proved to be more decisive than quantity.

Our basic research during the war reached a low level with the result that our reservoir of fundamental information is now low. In the future, Admiral Richardson feels that it is mandatory that our basic research exceed that of any potential enemy. The excessive time required to put a new design into full production must be reduced. The N.A.C.A. policy of working on basic research only should be maintained with development by industry and testing by the armed forces.

Our guided missiles should lead the world. Germany had a long lead, but failed to produce sufficient numbers be-

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fore it was too late for them to be decisive. Missile production is slow, partially because of too much theory and too little practical work. Guidance is the heart of the missile problem, and progress has been slow. Quoting General H. Vandenberg: "We must still rely on men in machines until the guidance is satisfactory."

Critical material problems as we approach large-scale production also pose another problem. We must develop substitute materials without loss of quality. Improved fuel consumption is also necessary to maintain our advantage. We must be first to develop nuclear flight, according to Admiral Richardson. The solution is in sight.

In spite of criticism of the deferment of men with scientific training and skills, this policy is vital to the preservation of our technical leadership. Admiral Richardson concluded by pointing out that a potent program for aeronautical training and research will go far toward establishing the leadership that we must have.

April also had two specialists' meetings. The first was on April 5 on the subject, "The Application of Elastic Energy Theory to the Swept Wing Aeroelastic Problem." The speaker was Arthur Ogness, Structures Engineer, El Segundo Division, Douglas Aircraft Company. The second meeting was held on April 12 and covered the subject, "The Aeroballistic Research Facility at the Naval Ordnance Laboratory." The speakers were Dr. Raymond J. Seeger, Chief, and Dr. H. H. Kurzweg, Assistant Chief, Aeroballistic Research Department, U.S. Naval Ordnance Laboratory.

Also on April 20, the Historical Associates met to hear Waldo Waterman speak on "Up in the Air for Forty Years." Mr. Waterman covered many interesting highlights of his long participation in the growth of the aircraft industry.

Montreal Section

G. E. Otter, *Secretary*

The May 29 meeting was held in the Mount Royal Hotel. B. W. Sznycer, Consulting Aeronautical Engineer and designer of the first Canadian helicopter, addressed the meeting on the subject, "The Design Principle of the First Canadian Helicopter."

Prior to coming to Canada in 1945 to commence work on the first Canadian helicopter, Mr. Sznycer had several outstanding achievements outside the helicopter field to his credit. He had designed and built a towed glider of 45-ft. wing span within a 5-week period; he had designed the first guided missile in the U.S.; and he had also designed skis for U.S. Air Force fighter planes and for Admiral Byrd's polar expedition. He was graduated from Warsaw Technical Institute in 1931.

The design and certification of the first Canadian helicopter was accomplished with an engineering staff consisting of Mr. Sznycer, Miss Gottlieb, and the part-time assistance of one engineer. The total development costs including two helicopters was slightly over $300,000.

Mr. Sznycer outlined some of the difficulties in the design, and among the major difficulties, financing and scepticism were of paramount importance. Because of limited funds, it was necessary to base the design on proved methods.

Serviceability was considered uppermost in the design considerations. To accomplish this, the engine was mounted horizontally and the transmission box was finned to provide adequate cooling of the oil; to prolong the life of the gears, rubber-mounted rear-rotor driveshaft bearings, among many other special features, were incorporated.

A considerable amount of trouble was encountered in the design of the canopy. Breaks in the pitching moment curves appeared at certain speeds, and the problem was finally overcome after designing several canopies by the use of a small horizontal tail surface located outside of the downwash from the main rotor.

Five reels of motion pictures had been taken to show all of the stages of development, including the static tests, strain-gage tests, first flight tests, and certification tests. The pictures showed a fully developed ground resonance that fortunately did *not* end in destruction. The pictures also showed the autorotational landings made during the certification tests in which ten autorotational landings were made from 2 to 10 ft. and from altitude without the use of the collective pitch control.

The helicopter has the distinction of being the first helicopter to be designed and certified in the British Commonwealth.

An interesting discussion followed the address.

Election of officers was held for 1951–1952 with the following results: Chairman, E. B. Schaefer; Vice-Chairman, E. H. Higgins; Secretary, H. V. Braceland; and Treasurer, W. H. D. Hanchet.

Washington Section

C. Don Auld, *Secretary*

"The Effects of the New War Emergency on Research Trends" constituted the theme of the papers presented at the March 20 meeting. This theme was developed by speakers from the Washington Headquarters Staff, N.A.C.A. Their papers were prefaced by Dr. Hugh L. Dryden, Director of the N.A.C.A., who spoke briefly concerning N.A.C.A. research efforts and indicated that the program theme was to be expressed by a sampling of N.A.C.A. activities.

The first paper, entitled "The Aerodynamics Scene," was presented by Milton B. Ames, Chief, Aerodynamics Research Branch. Mr. Ames grouped the study of the science of aerodynamics by the N.A.C.A. under two general categories: (1) basic research and (2) applied research and development.

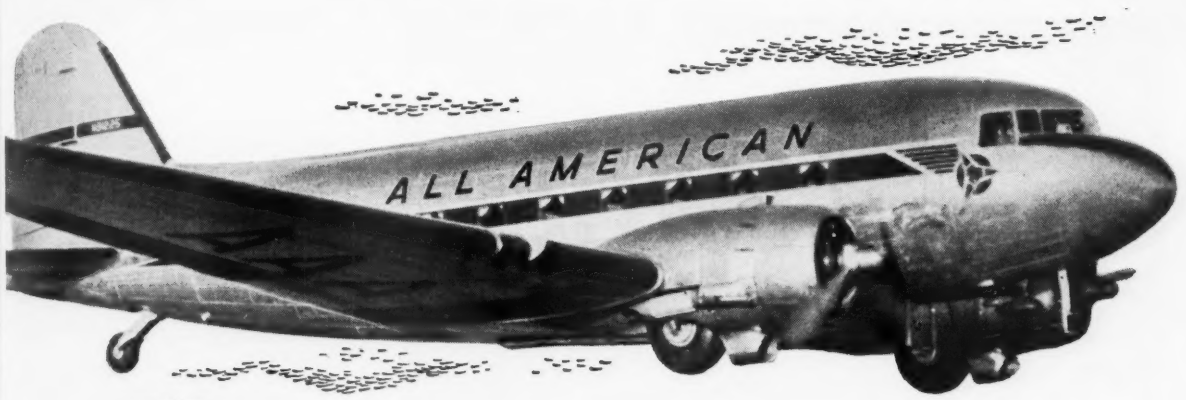
Prior to World War II, the greater portion of the N.A.C.A. effort was directed toward basic research. The urgent need for combat aircraft designs, created by World War II, caused a nearly complete reversal of this picture, showing the greater percentage of effort being directed toward application of research to development of prototype aircraft. The end of the war found the fund of basic aerodynamic information seriously depleted, and N.A.C.A. activities were, of necessity, again heavily weighted toward basic research. The years 1948–1950 have shown greater progress in advancement of the study of aerodynamics than during any previous period.

The present war emergency has again required a shift in emphasis. However, the scene is somewhat different this time. Aircraft manufacturers are better able to assume the responsibilities of development and have at their disposal more adequate facilities for this work. The present intent of N.A.C.A. is to direct greater than 50 per cent of their activity toward building up a pool of basic aerodynamic information.

Mr. Ames closed his paper with a specific illustration of N.A.C.A. work on a particular problem, the delta-wing configuration. He presented slides outlining his steps in acquiring the basic information for such a configuration through the final application to development of the XF92 aircraft.

The next speaker, F. W. Phillips, presented a paper entitled "The Critical Aircraft Materials Picture." Mr. Phillips stated that the new war emergency has had no effect on materials research trends. These trends, as in the past, are toward improved performance and reliability of aircraft. The principal effect has been to bring to the front problems associated with availability of materials.

Mr. Phillips cited the case of transition from reciprocating to jet- or turbine-powered airplanes as an example effecting the concept of materials supply. Three approaches to this and other availability and supply problems, involving greatly increased demand for materials not previously produced in large quantity, were outlined.



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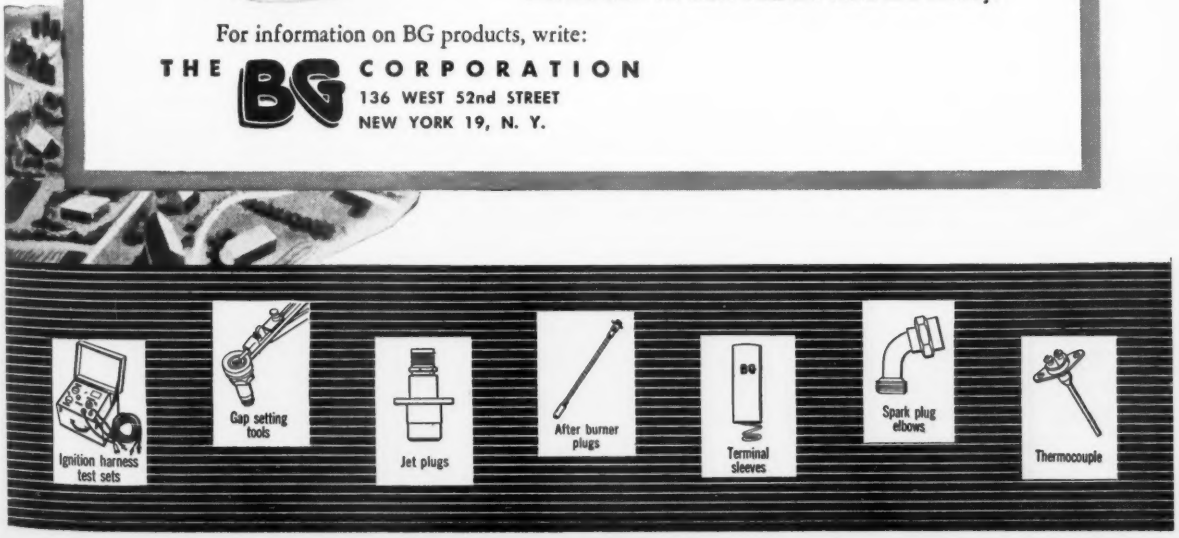

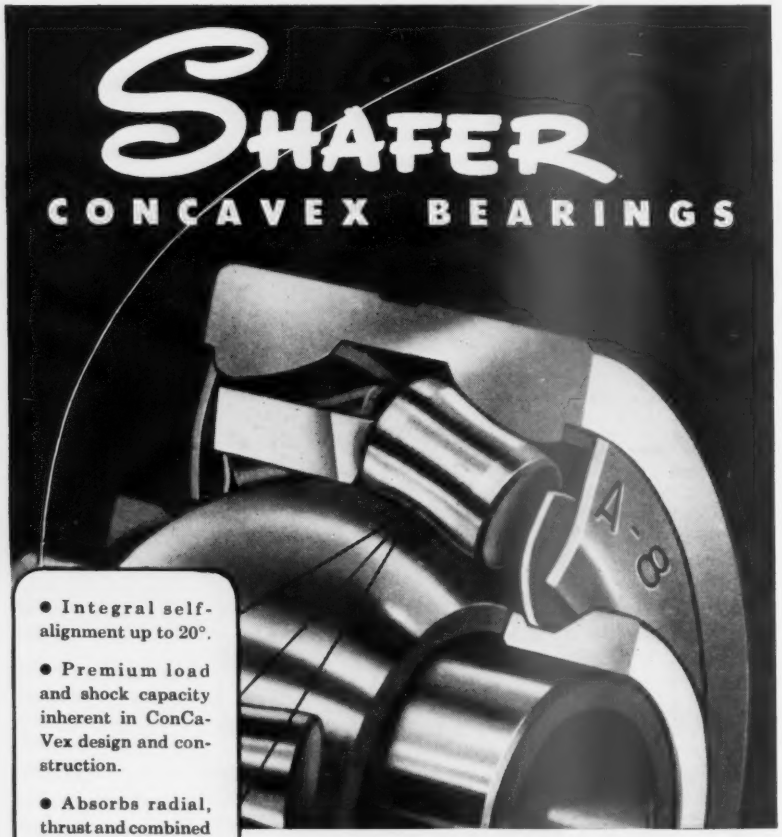

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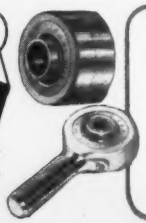

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The first approach is through substitution of less critical materials for critical materials. The second is conservation of materials—i.e., more efficient production methods directed toward reducing wastage and scrap in production processes. The third is through design ingenuity, more efficient design based on a more thorough knowledge of operating conditions of the end product and the properties of materials used in the design.

The last speaker, H. E. Alquist, spoke on "The Problems of Jet Fuels." Here the primary problems of quantity of fuels can be approached through more efficient use of existing fuels and development of fuels that can be produced more simply and faster.

▶ An election of officers which was held recently had the following results: Chairman, Harold Hoekstra; Vice-Chairman, Donald R. Eastman; Secretary, J. H. Sidebottom; and Treasurer, J. E. Dougherty. These new officers were guests of the Section at the May 8 dinner and were introduced to the members at the meeting following the dinner.

Wichita Section

Melvin H. Snyder, Jr., *Secretary*

In place of the Annual National Personal Planes Meeting, the Wichita Section sponsored a Mid-West Regional Meeting on the subject of "Personal Plane Report—1951." The report was given by a panel of experts and the moderator was Ted Wells, Vice-President and Chief Engineer, Beech Aircraft Corporation. The panel included Herb Rawdon, Assistant Chief Engineer, Beechcraft; Major James Hill, U.S.A., Aircraft Procurement Representative, Cessna Aircraft Company; Tom Salter, Vice-President and Chief Engineer, Cessna; and Frank Martin, Western Sales Manager, Cessna.

Representatives of Government, education, and industry were on hand. Those at the speakers' table included Ernest W. Robischon, I.A.S. Western Manager, who briefly greeted the members on behalf of the National Officers; William Weeks, District Manager, C.A.A., Kansas City; Kenneth Razak, Director, School of Engineering, University of Wichita; John Gaty, Vice-President, Beech; and Jerry Gordon, Past-Chairman, Wichita Section.

Although the speakers had been assigned various phases of the personal aircraft business, they all (with the exception of Major Hill) drifted toward the subject of the use of the personal aircraft by business concerns. They were in agreement that the present trend in the personal-plane field is toward increased use of the planes as executive and sales vehicles for the industry. It

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was felt that this trend is good for aviation.

Mr. Rawdon opened the meeting with a discussion based on statistics showing the usage of the executive aircraft. As he pointed out, the usage of these aircraft is expanding, both in types of applications and in numbers of users.

Major Hill outlined the development of the Army's program that utilizes personal-type aircraft. He feels that the present trend in Army use is for an increase in the employment of these aircraft for sure transportation in addition to their uses for observation, fire control, and evacuation of the wounded. He admitted, in answer to a question from Harold Zipp of Boeing Airplane Company, that military requirements are necessitating a departure from pure off-the-shelf purchases and that special equipment is being built into the planes. Tom Salter expressed the opinion that this move would improve personal planes of the future by getting many of these special items into production and causing their price to come down to where they could be afforded by personal-plane owners. This follows the trend started by World War II. The prewar nonstandard fittings were contrasted with the postwar AN fittings, which are now standard on personal aircraft.

Frank Martin's subject was the personal operator. He stressed the point that the personal-plane industry has advanced in the past decade to where it is on a firm business footing. To illustrate his point, he contrasted his prewar personal-plane sales experiences with present conditions.

Tom Salter presented a new method of considering safety records of various types of transportation. His theme was "It's the Vehicle That Has the Accident, Not the Rider," and he presented data showing the number of fatalities per vehicle-mile. The result showed that the safest vehicles are automobiles and personal aircraft. He also compared the large number of persons, outside of the vehicle, killed by trains and automobiles with the few killed by personal planes. He feels that one of the reasons for the improvement of the flight safety records is the decrease in the amount of "buzzing."

Section Chairman Douglas Heimburger presided; 98 persons attended the meeting, which was held in the Allis Hotel, Wichita.

Student Branches

Agricultural and Mechanical College of Texas

A joint meeting of the I.A.S. and S.A.E. student branches was held on May 8. The speaker was Colonel Black, U.S.A.F., Carswell Air Force Base, who talked on "The B-36 in Warfare." Student Chairman Robert Bryan English led the meeting; 40 persons were present.

University of Alabama

On May 10, an election of officers for the fall semester was conducted by the Student Branch Chairman, Major Mortimer D. Marks, U.S.A.F. The following men were elected: Chairman, William E. Carr; Vice-Chairman, Mark C. Gregoire; Secretary, John P. Perdue; and Treasurer, John T. Wheeler.

University of Cincinnati

Student Member Fred S. Silberberg, a Senior at the University, gave a talk on the "Early Development of the V-2 Rocket" at the May 10 meeting. Mr. Silberberg was selected as the winner of the I.A.S. Award for the best student paper; John L. Martz, another Student Member, was chosen as the winner for the I.A.S. Award for scholastic achievement. Chairman Dale H. Whitford presided; 36 persons were present.

Elections of officers were held on May 17 with 23 members present. The following will assume offices designated: Chairman, Dale A. Benethum; Vice-Chairman, Robert J. Wilson; Secretary, Vincent E. Kearney; and Treasurer, Richard L. Wohlen.

University of Colorado

Twenty-five members were present at the April 26 meeting at which Chairman Myron J. Miller presided. Elections were held with the following results: Chairman, Burt Benson; Vice-Chairman, Arthur MacFarland; Secretary, Jane Judge; and Treasurer, Bob Burleson. The speaker of the evening was Mr. Kottas, Chief, Flight Propulsion Research Laboratory of the N.A.C.A., who spoke on the subject, "N.A.C.A." A film, *Ames Aeronautical Laboratory in Action*, was shown in conjunction with the talk.

Cornell University

The theses of two students about to receive their M.Aero.E. degrees were presented at the May 15 meeting, which was presided over by Chairman Alfred Ritter. There were 30 persons present.

The first paper presented was that of Charles Boris Notess, Engineer, Cornell Aeronautical Laboratory. Its subject was on the "Stability of Supersonic Aircraft." The second paper was on "Minimum Drag of Supersonic Wings" and was prepared by Ralph William Detra, Graduate Student, Graduate School of Aeronautical Engineering, Cornell. Mr. Notess delivered his own paper; Mr. Detra's was submitted by M. B. T. George, I.A.S. Cornell Student Branch Vice-Chairman.

University of Florida

At the May 15 meeting, the following officers were elected for the 1951 fall semester: Chairman, Roy F. Dutton; Vice-Chairman, Ross F. Dutton; Corresponding Secretary, Robert S. Bailey; Recording Secretary, Alan S. Meadows; and Treasurer, Philip F. Oestricher. The meeting was concluded by the showing of the film, *The Phantom*. Chairman Costa Francisco presided; 30 persons were present.

Kansas State College of Agriculture and Applied Science

Elected to serve as student branch officers for the 1951 fall semester are: Chairman, Harold Osborn; Vice-Chairman, Marvin Smith; and Secretary-Treasurer, Irvin Kroenke. Prof. Frank J. McCormick will be Honorary Chairman.

University of Maryland

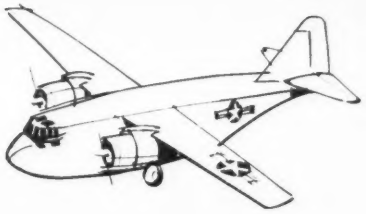
The films, *PBM-3 Wing Destruction Test*, *Operation Crossroads*, and *The Air Force Voodoo*, were shown at the meetings of April 25, May 9, and May 14, respectively.

On May 11, 15 members made a faculty-sponsored tour of The Glenn L. Martin Company.

The meeting of May 17 was opened by Chairman William S. Bissell with 34 persons present. The following officers were elected for the 1951–1952 school year: Chairman, Allen A. Bowers; Vice-Chairman, Robert T. Hall; and Secretary-Treasurer, Robert H. Larsen. The speaker at this meeting was R. T. Patterson, Head of the Supersonic Wind Tunnel, David Taylor Model Basin, Carderock, Md. Mr. Patterson's subject was the "Performance of Intermittent Supersonic Wind Tunnels." The meeting was concluded with a film, *Pylon Dusters*.

On May 22, 12 members made a faculty-sponsored tour of the Hagerstown, Md., plant of Fairchild Aircraft Division, Fairchild Engine and Airplane Corporation.

At the May 31 meeting, two films, *The Story of the Sikorsky Helicopter* and *Air*



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Force Goblin, were shown to the 30 persons present.

University of Minnesota

On May 22, Lt. Colonel Knutson, U.S.A.F., gave an address to the 40 persons present on "The Role of M.A.T.S. in Supplying Military Operations." Colonel Knutson is Chief, Airlift Control Branch, Military Air Transport Service.

The new officers for the coming academic year are: Chairman, Warren Eberspacher; Vice-Chairman, Floyd Livingston; Secretary, Paul Haglin; and Treasurer, Tom Collins.

North Dakota Agricultural College

From May 5 to May 11, Student Members Albert Mahrer, Donald Trett, Robert Flynn, Wesley Martin, and Robert Brun made an inspection trip to the Cessna, Beech, and Boeing plants of Wichita, Kan. They were accompanied by Prof. R. K. Wattson, Jr.

Northrop Aeronautical Institute

On May 22 and May 24, field trips were made to the Los Angeles branch of the Aluminum Company of America. Eighty-six persons attended the trips.

On May 25, 105 persons attended a dinner meeting held in the I.A.S. Los Angeles building. J. C. Chaffee presided. Guest speakers were Lt. Col. Carl E. Jackson, U.S.A.F., Head, West Coast Engineering Field Office, Air Materiel Command, and Carlos Wood, Head, Preliminary Design, Douglas Aircraft Company. Colonel Jackson spoke on the "Determination of Military Aircraft Specifications"; Mr. Wood gave an address on the "Preliminary Design of a Military Aircraft." Delegations from California State Polytechnic College, Cal-Aero Technical Institute, and Northrop Aeronautical Institute were present.

The Pennsylvania State College

On May 23, two films on various types of rockets were shown to the 25 attending members. The films were on loan from the Department of the Navy. Chairman George F. Page presided.

Rensselaer Polytechnic Institute

Elections of officers were held at the May 16 meeting with the following results: Chairman, J. Williams; Vice-Chairman, J. P. Joyce; Secretary-Treasurer, O. E. LaPlant; and Assistant Secretary-Treasurer, R. J. Wasicko. Prof. A. J. Fairbanks is the Faculty Adviser.

Riddle McKay College of Aeronautics

As a result of elections held at the April 26 meeting, the following officers were elected: Chairman, Morton Rifkin; Vice-Chairman, Clare Kline; Secretary, Warren Van Tassell; and Treasurer, John Williams. A motion picture, *Structures of the B-25*, was shown. The meeting was attended by 16 persons and presided over by Chairman Robert E. Frazer.

Stanford University

On May 11, Chairman James L. Taylor presided over a short business session at which it was announced that Ralph W. Franks, now Vice-Chairman, and John L. McCloud will assume the offices of Chairman and Vice-Chairman, respectively. These changes will be effective in September for the remainder of 1951.

The rest of the meeting was given over to the Annual Student Branch Lecture Award competition in which four Student Members participated. Judges for the competition were Prof. Elliott G. Reid and Volney C. Finch. Following is a list of the papers presented and their authors: "Helicopter Control and Operation," by Richard Olshausen; "Aircraft Powerplants," by Joseph I. Concha; "Realistic Aircraft Speed-Range Performance Analysis," by James L. Taylor; and "The DC-4 Cockpit," by John L. McCloud. The winner was to be announced at a later date.

Sixteen persons went on a field trip to the N.A.C.A. Ames Aeronautical Laboratory on May 31. Messrs. Wiley and Triplett of the N.A.C.A. staff gave a conducted tour of several of the Ames research facilities.

Syracuse University

The May 18 meeting was called to order by Chairman Herb Horn with nine members in attendance. Election of officers for the fall semester was held with the following results: Chairman, Jack Andrews; Vice-Chairman, Spence Weller; Secretary, Charles Knickerbocker; and Treasurer, William Danz. The Honorary Chairman is Prof. M. E. Barzelay.

Tri-State College

A North American Aviation film, *Structures*, was shown to the 45 people who attended the May 10 meeting. Chairman Ben K. Gantt presided.

Chairman Ben K. Gantt led the May 24 meeting at which nominations of officers for the summer term took place. Two films, *One Man Task Force* and *Then There Were Four*, were shown to the 21 persons present.

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University of Tulsa

Fourteen persons attended the May 17 meeting at which Chairman James Owen Anderson presided. William S. Jones gave a talk on the "Drag of Swept Wings." It was for this lecture that Mr. Jones was declared the winner of the annual I.A.S. senior lecture award. Mr. Anderson was judged the winner of the annual I.A.S. scholastic award.

An election of officers was held with the following results: Chairman, E. W. Garrison; Vice-Chairman, Jack Owens; and Secretary-Treasurer, Reuben D. Tye.

U.S.A.F. Institute of Technology

The May 21 meeting was called to order by the Chairman, Major Eugene Blue. Major R. W. West, Captain D. E. Whipple, and Capt. R. J. Fowler, all of whom are Student Members, read their term paper for Aerodynamics entitled "Inflight Refueling." The talk was followed with two films on the same subject.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Elected to Associate Fellow Grade

Patterson, Gordon N., Ph.D., Dir., Institute of Aerophysics & Prof. of Aerodynamics, Dept. of Aero. Engineering, University of Toronto.

Transferred to Associate Fellow Grade

Bergen, William B., S.B.Ae.E., Vice-President & Chief Engineer, The Glenn L. Martin Co.

Dommasch, Daniel O., M. of Ae.E., Chief Engineer & Chief Instructor, Test Pilot Training Div., Naval Air Test Center (Patuxent River); Visiting Prof., University of Maryland.

Fink, Frank W., B.S.M.E., Chief Engineer, Consolidated Vultee Aircraft Corp. (San Diego).

Schaefer, Oswald J., B.S.Ae.E., Chief, Production Design Dept., The Glenn L. Martin Co.

Elected to MEMBER Grade

Barnett, Charles A., B.S. in M.E., Chief Engineer, Kellett Aircraft Corp.

Berndt, Sune B., Civing., Research Engineer, assigned to the Royal Institute of Technology (Stockholm), Royal Swedish Airbord.

Black, Max I., B.S.C., Field Representative, California Aeronautics Commission.

Boegel, Maurice J., B.S., Section Engineer—Aviation, Gulf Research & Development Co.

Harris, Thomas J., Power Plant Development Engineer, American Airlines, Inc.

Hoben, Harold E., B.S. in A.E., Dir.-Aircraft Analysis, American Airlines, Inc.

Lefever, Charles W., B.A., Administrative Executive, Prewitt Aircraft Co.

Maxwell, Frederick W., Jr., M.S., Lt. Comdr., U.S.N.; Engineering Officer, Naval Air Rocket Test Station, Dover, N. J.

McGuire, R. C., B.S.M.E., Development Engineer—Structures & Systems, American Airlines, Inc.

Nelson, Erik, Executive Asst. to President, Air Carrier Service Corp.

Raiguel, E. H., Instrument & Electrical Development Engineer, American Airlines, Inc.

Strieter, Robert M., M.S. in Ae.E., Lt. Comdr., U.S.N.; Asst. Development Officer, Air Development Squadron One, Naval Air Station (Key West).

Tajirian, George K., B.S. in M.E., Engineer-Designer, Consolidated Vultee Aircraft Corp. (Ft. Worth).

Watts, Linden L., Jr., M.E., Model Design Engineer, Grumman Aircraft Engineering Corp.

Withington, Holden W., S.M., Power Plant Unit Chief, Boeing Airplane Co. (Seattle).

Transferred to MEMBER Grade

Battaglia, Joseph C., B.S., Engineering Service Representative, Civil Aeronautics Administration.

Ford, Francis M., B.S., Captain, Instructor Pilot & Ground School, Instructor, U.S.A.F.

Pursifull, L. J., B.S.Ae.E., Civilian Section Chief, Research & Development Station, Air Section Development Div., U.S.A. (Fort Eustis).

Sentker, Lawrence C., B.S.M.E., Aero. Engineer, Office of Aviation Safety, Civil Aeronautics Administration.

Stanbrook, Alan, B.Sc. in Math., Scientific Officer, Ministry of Supply, Royal Aircraft Establishment (England).

Elected to Associate Member Grade

Bartlett, Richard L., Engineer-Liaison Representative, Bell Aircraft Corp.

Legris, Joseph A., B.A.Sc., Partner, Ridout & Maybee (Patent Attorneys).

Unger, Thomas J., Survey Pilot, Photographic Survey Corporation.

Transferred to Associate Member Grade

Krekorian, K. A., Flight Test Analyst, North American Aviation, Inc.

Elected to Technical Member Grade

Probstein, Ronald F., M.S.E., Research Asst., Aero. Engineering Dept., Princeton University.

Transferred to Technical Member Grade

Ackerman, Arnold J., Jr., A.A. Detail Draftsman, Beech Aircraft Corp.

Ackermann, W. O., Jr., B.S.Ae.E., Student, University of Illinois.

Anderson, J. Owen, B.S. in Ae.E., Engineering Draftsman "B," Douglas Aircraft Co., Inc. (Tulsa, Oklahoma).

Antonucci, Frank R., Jr. Engineer, Naval Aero-Ordnance Physics Lab., Consolidated Vultee Aircraft Corp. (Daingerfield).

Armstrong, William O., B.S. in Ae.E., 2nd Lt., U.S.A.F.

Bailey, Cecil D., B.S., 1st Lt. & Pilot Instructor, U.S.A.F.

Barbaccia, Ignatius A., B.Ae.E., Mechanical Engineer, Coles Signal Lab.

Bell, James E., Jr., Design Engineer, Century Engineers, Inc.

Benjamin, Robert B., Ae.E., Aero. Engineer GS-5, Air Development Command, Wright-Patterson Air Force Base.

Beyer, David D., B.S. in Aero., Engineering Draftsman, Engineering Dept., North American Aviation, Inc.

Bias, Andrew W., B.S., Engineering Draftsman, North American Aviation, Inc.

Bisceglia, Angelo M., Flight Engineer, Taylorcraft, Inc.

Burness, Gordon L., Squadron Leader, Air Defence Group Hq., R.C.A.F.

Burns, Marjory Joan, B.S.Ae.E., Research Asst., Structures Dept., Armour Research Foundation.

Campbell, Thomas E., Jr., B.S. (Aero.), Engineering Draftsman, North American Aviation, Inc.

Castaldo, Edward J., Draftsman, Aerophysics Lab., North American Aviation, Inc.

Clark, D. Gene, B.S.A.E., Technical Writer, Lockheed Aircraft Corp.

Coleman, David L., B.S. (A.E.), Jr. Engineer-Missile Test Analyst, Consolidated Vultee Aircraft Corp. (San Diego).

Cotecchia, Ugo A., M.S.E., Research Asst., University of Michigan.

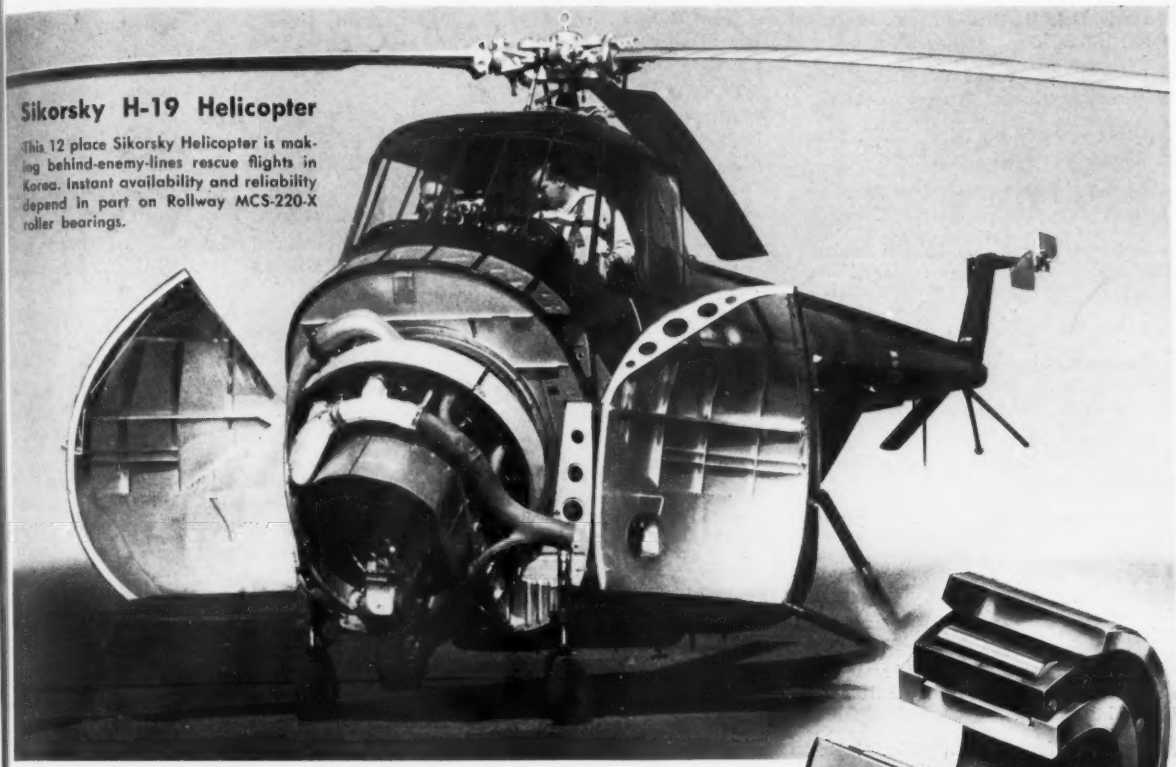
Covington, William S., B.S., A.T.E., Career Guidance Specialist, U.S.A.F.

Crites, Claude W., B.S. in Aero., Asst. Checker, Engineering Drawings, McDonnell Aircraft Corp.

Curtin, Daniel C., B.S.Ae.E., Engineering Draftsman, Ralph H. Decker, Inc.

Dallas, Stephen S., B.Ae.E., Aerodynamicist, Piasecki Helicopter Corp.

Dansby, Ted, Sr., B.A.E., Graduate Asst.-Wind Tunnel Operator, Georgia Institute of Technology.



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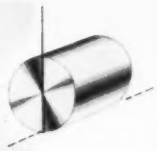

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Di Salvo, Joseph, Draftsman, Sikorsky Aircraft Div., United Aircraft Corp.

Edwards, Ellis B., Lt., Pilot & Student Officer, U.S.A.F. (Keesler Air Force Base).

Eisley, Joe G., B.S.

Engstrand, Joseph G., Jr., B.S.E., Design Engineer, Surface Controls, Grumman Aircraft Engineering Corp.

Erickson, Arthur W., B. of Ae.E., Engineering Draftsman, Douglas Aircraft Co., Inc. (Long Beach).

Faitel, Joseph R., Asst. Engineer, Domanco Co.

Fehr, Thomas W., B.S., Graduate Engineering Asst., Power Plants Section, Aero. Engineering Dept., University of Illinois.

Fleming, James B., B.Ae.E., Armament Liaison Engineer, Douglas Aircraft Co., Inc. (El Segundo).

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Greene, Hubert L., M.S. in Engineering, Exterior Ballistician, Ordnance Rocket Center, Redstone Arsenal.

Guerrero, Guillermo J., Jr., Sgt. & Career Guidance Specialist, U.S.A.F.

Guinn, S. Lester, Jr., B.S. in Ae.E. & Bus. Admin., Jr. Engineer, Boeing Airplane Co. (Seattle).

Gursahaney, Heman J., M.S. in A.E., Aerodynamicist-Engineer "B," Canadair, Ltd.

Hackney, Donald I., M.S., Lt., U.S.A.F.; Design & Development Officer, Hq., Air Development Force, Wright-Patterson Air Force Base.

Heine, Victor H. C., B.S.E. (Aero.), Draftsman, Bell Aircraft Corp.

Hojnowski, Walter M., B.S. in M.E. (Aero.), Jr. Engineer, McDonnell Aircraft Corp.

Hood, George M., Captain & Pilot, U.S.A.F., Wright-Patterson Air Force Base.

Hooks, Bentley C., Jr., B.S., 2nd Lt. & Student Officer, U.S.A.F.

Horn, Robert P., Lt. & Student Officer, Air Force Institute of Technology, assigned to Procurement Field.

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Johnson, Kenneth O., B.S., Engineer—Stress Analysis, Allison Div., General Motors Corp.

Jones, William S., B.S.Ae.E., Aero. Engineer, Wright-Patterson Air Force Base.

Juhasz, Andrew A., Pilot & Colonel—Procurement, U.S.A.F., Wright-Patterson Air Force Base.

Konersman, William A., B.Ae.E., Air Loads Engineer, McDonnell Aircraft Corp.

Koshiol, George P., B.S. in Ae.E., Field Engineer (Service Representative), Consolidated Vultee Aircraft Corp. (Fort Worth).

Larson, Milton C., A.A. in Ae.E., Engineering Draftsman Sr., Goodyear Aircraft Corp.

Lebo, Carson E., Jr., Draftsman, The Glenn L. Martin Co.

Little, Robin K., B.S. in Ae.E., Jr. Engineer "A," Preliminary Design Group, Boeing Airplane Co. (Seattle).

Lomax, Ted L., Jr. Engineer "B," Boeing Airplane Co. (Seattle).

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Martz, John L., A.E.

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Mitchell, Robert F., B.S., Lt. & Student Pilot, U.S.A.F.

Morcock, Dougald S., B.A.E., Jr. Engineer, Fuselage Group, Consolidated Vultee Aircraft Corp. (Ft. Worth).

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Ralls, Jack A., A.E., Test Engineer (Instrumentation), Northrop Aircraft, Inc.

Ransleben, Guido E., Jr., B.S., Engineering Draftsman "B," Douglas Aircraft Co., Inc. (Long Beach).

Reiner, Robert J., B. of M.E. (Aero.), Power Plant Engineer, Power Plant Lab., Air Development Force, Wright-Patterson Air Force Base.

Riepe, Quenten A., B.A.E., Major, U.S.A.F.; Rand Project Officer, Office of Air Research, Wright-Patterson Air Force Base.

Rodgers, Robert R., Jr., B.S. in A.E., Jr. Engineer "B," Boeing Airplane Co. (Seattle).

Sadorf, Richard J., Lt., Aircraft Controller & Pilot, U.S.A.F.

Sajeski, Theodore R., Engineering Draftsman, The Glenn L. Martin Co.

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Schroeder, Leslie W., A.A., Jr. Designer, Chance Vought Aircraft Div., United Aircraft Corp. (Dallas).

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Smith, Dickson J., B.S.E., Jr. Engineer "A," Boeing Airplane Co. (Seattle).

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Stern, Perry, B.S., Stress Analyst, North American Aviation, Inc.

Sterzik, Kurt E., B.S.E. (Aero.), Mathematician "B," North American Aviation, Inc.

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Todnem, John E., B.Ae., Jr. Engineer, B.O.P. Assy. Div., General Motors Corp.

Turnbull, Norman L., B.S. in Ae.E., Jr. Test Engineer, Pratt & Whitney Aircraft Div., United Aircraft Corp.

Vander Velde, Wallace, B.S. in Ae.E.

Veit, William P., A.A. in Ae.E., Engineering Draftsman, Goodyear Aircraft Corp.

Wack, Leo A., B.S.Ae.E., Senior Draftsman, Fixed Equipment Group, Goodyear Aircraft Corp.

Walker, Clarence L., B.S., Engineering Draftsman, North American Aviation, Inc.

Walsh, James D., Major & Pilot, assigned to Supply Div. of Air Materiel Command, U.S.A.F.

Waterman, Gerald B., M.A.Sc., Flight Lt. & Aero. Engineer, R.C.A.F.

Wienber, Harold F., Captain, Pilot & Engineer, U.S.A.F., Wright-Patterson Air Force Base.

Wieneke, Robert E., Tool Engineer, North American Aviation, Inc.

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I. PERIODICALS AND REPORTS

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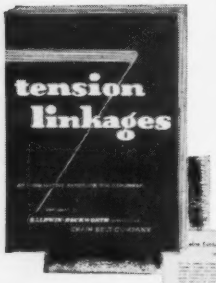

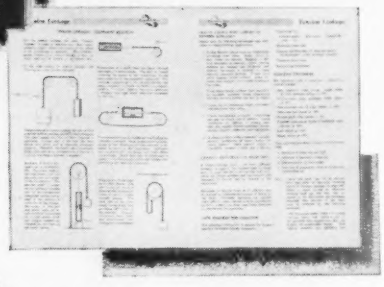

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Aerodynamics (2)

Flight Characteristics at High Mach Numbers. V. Outman and G. V. Graff. *Aircraft Engineering*, Vol. 23, No. 267, May, 1951, pp. 139–142, illus.

Development test flying of the McDonnell Banshee at high subsonic Mach Numbers. Test procedure included tuft tests, in which tufts of yarn were fastened to the wing and tail surfaces, and the in-flight conditions were photographed. Photographs show modifications of the tail surfaces to eliminate compressibility effects.

Flight Characteristics of the Boeing B-47 Stratojet. Robert M. Robbins and William H. Cook *S.A.E., National Aeronautic Meeting, April 16–19, 1951, Preprint No. 617.* 8 pp., illus.

Wind-Tunnel Tests on the Shetland. C. H. E. Warren and R. E. W. Harland. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2571*, 1951 (October, 1942). 25 pp., illus. 5 references. British Information Services, New York. $1.15. Aerodynamic data on the Short-Saro R.14/40 Shetland.

Wind-Tunnel Tests on the Experimental High Lift M.18. R. Hills, E. C. Brown, M. A. Morrison, and H. V. Becker. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2453*, 1951 (June, 1942). 13 pp., illus. British Information Services, New York. $0.65.

Wind-tunnel tests of slipstream effects, yawing and rolling moment due to sideslip and rudder power on a wing with a 40 per cent chord slotted flap, inset ailerons, and full-span leading-edge slots fitted to the fuselage of a Phillips & Powis M.18 trainer.

Wind Tunnel Tests on the Supermarine S.24/37, a High-Wing Monoplane with a Variable-Incidence Wing. H. Davies, J. E. Adamson, and J. Seddon. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2451*, 1951 (March, 1941). 39 pp., illus. British Information Services, New York. $1.60.

Results of tests on a 1/6-scale model in the R.A.E. $11\frac{1}{2}$- by $8\frac{1}{2}$-ft. tunnel at 121.6 ft. per sec. Lift, drag, pitching moments, and elevator efficiency were measured with the engine off; the effect of slipstream on lift, longitudinal stability, and trim were measured for take-off and normal flight conditions.

Tests on A. W. Apollo (Brab IIB) in the N.P.L. Compressed Air Tunnel. C. Salter, C. J. W. Miles, and P. S. Pusey. *Gt. Brit., Aeronautical Research Council, Current Papers No. 40*, 1951 (December 22, 1949). 39 pp., illus. British Information Services, New York. $1.60. Tests on a $\frac{1}{25}$-scale model at Reynolds Numbers up to 5.0×10^6 to study the effects of slotted flaps, elevators, tail plane, body-wing fillets, and freely rotating propellers.

Free-Flight Tests on Kites in the 24-Ft. Wind Tunnel. S. B. Jackson. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2599*, 1951 (March, 1942). 18 pp., illus. British Information Services, New York. $0.90.

BOUNDARY LAYER

The Laminar-Turbulent Transition in a Boundary Layer. I. H. W. Emmons. *Journal of the Aeronautical Sciences*, Vol. 18, No. 7, July, 1951, pp. 490–498, illus. 7 references.

Observations of laminar-turbulent transition and the mechanics of turbulence with a water-table analogy of supersonic flow. The turbulence in transition is intermittent; every point is turbulent at some time during the process. The theory is applied to available flat-plate data.

Method of Successive Approximations for the Solution of Certain Problems in Aerodynamics. M. E. Shvets. (*Prikladnaia Matematika i Mekhanika*, Moscow, Vol. 13, No. 3, 1949, pp. 257–266.) *U.S., N.A.C.A., Technical Memorandum No. 1286*, April, 1951. 20 pp., illus. 8 references.

Approximate solution by boundary-layer and successive approximation methods of the diffusion equation, boundary-layer equation of a flat plate in incompressible flow, motion of a fluid in laminar boundary layer with a longitudinal pressure drop, heat transfer in laminar boundary layer on a plate in incompressible flow, cooling of heated sphere by laminar flow of fluid at low Reynolds Numbers, free convection at a plane vertical wall, and stationary turbulent diffusion.

Boundary Layers and Skin Friction in High-Speed Flow. A. D. Young. *Royal Aeronautical Society, Journal*, Vol. 55, No. 485, May, 1951, pp. 285–302, illus. 28 references.

Review of research on boundary layers at high speeds; characteristics, behavior, and stability of laminar and turbulent bound-

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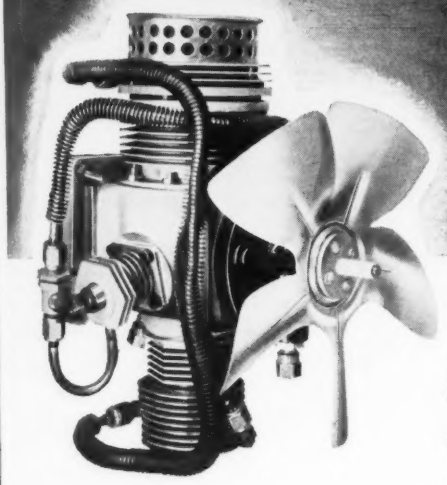

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ary layers; behavior of boundary layers in compressible flow; shock-wave interaction; scale effects. Schlieren photographs show boundary-layer buildup and separation for various flow conditions.

A Study of Methods to Increase the Lift of Supersonic Airfoils at Low Speed. A. D. Pollock, Jr., and F. F. Peck. *California Institute of Technology, Thesis for the Professional Degree in Aeronautical Engineering*, 1947. 34 pp., illus. 10 references.

Low-speed investigation of the lift, drag and stalling speed characteristics of a 10 per cent symmetric double-wedge airfoil tested with nose flaps, trailing-edge split flaps, and boundary-layer control. Test procedure, apparatus, and model construction are given. A sheet of high-velocity air was blown out over the airfoil upper surface through a spanwise slit located at 0.15*c* for boundary-layer studies.

Possible Application of Blade Boundary-Layer Control to Improvement of Design and Off-Design Performance of Axial-Flow Turbomachines. John T. Sinnette, Jr., and George R. Costello. *U.S., N.A.C.A., Technical Note No. 2371*, May, 1951. 32 pp., illus. 14 references.

Analysis of boundary-layer control by the suction-slot method for turbine blades. A potential-flow method of designing blades for boundary-layer control by prescribing the velocity distribution along the blade and in the slot is developed. The effect of the boundary layer on the slot is also studied.

On the Compressible Boundary Layer over a Flat Plate with Uniform Suction. Henry G. Lew. (*Reissner Anniversary Volume*, Ann Arbor, Mich., 1949, pp. 43–60.) *Polytechnic Institute of Brooklyn*, 1949. 20 pp., illus. 8 references. Preliminary study of the effect of homogeneous suction to determine the effect of distributed suction on delaying the transition of the laminar boundary layer.

The Velocity Distribution in the Laminar Boundary Layer Between Parallel Streams. R. C. Lock. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 4, Part 1, March, 1951, pp. 42–63, illus. 2 references. Investigation of the boundary layer between two fluids of different densities and viscosities.

The Turbulent Boundary Layer in a Compressible Fluid with Positive Pressure Gradient. Carlo Ferrari. *Journal of the Aeronautical Sciences*, Vol. 18, No. 7, July, 1951, pp. 460–477, illus. 10 references.

Analysis of the effects of a turbulent boundary layer on the velocity distribution of the layer, thickness distribution, drag coefficient, and separation of the stream from the wetted wall. An equation of motion is constructed for the flow on the inside portion of the layer. Solution of this equation leads to a determination of the position where separation takes place. Subsonic and supersonic velocity distributions are used to check the procedure.

CONTROL SURFACES

Note on the Lift and Profile Drag Effects of Split and Slotted Flaps. A. D. Young and P. A. Hufton. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2545*, 1951 (September, 1941). 20 pp., illus. 45 references. British Information Services, New York. $1.00. Analysis of wind-tunnel and flight-test data to provide a method of predicting lift and profile-drag increments.

The Induced Drag of Flapped Elliptic Wings with Cut-Out and with Flaps That Extend the Local Chord. A. D. Young. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2544*, 1951 (February, 1942). 12 pp., illus. 2 references. British Information Services, New York. $0.65.

Calculations have been made of the induced drag of flapped elliptic wings covering a range of aspect ratios from about 4 to 12, flap spans from 0.2 to 1.0 of the wing span, and a range of flap cut-outs from 0 to 0.6 of the wing span.

Effect of Aspect Ratio on the Low-Speed Lateral Control Characteristics of Unswept Untapered Low-Aspect-Ratio Wings. Rodger L. Naeseth and William M. O'Hare. *U.S., N.A.C.A., Technical Note No. 2348*, May, 1951. 47 pp., illus. 12 references.

Wings of aspect ratios 1.13, 2.13, 4.13, and 6.13 with 0.25*c* sealed ailerons of various spans and spanwise locations were tested at $M = 0.26$ to determine the effect of aspect ratio on control characteristics, lateral control and basic aerodynamic characteristics, and lateral-stability parameters. Test results were compared with three theoretical methods of estimating aileron effectiveness.

Flight Tests of a Youngman Flap on Fairey P.4/34 K.7555. M. B. Morgan and D. E. Morris. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2547*, 1951 (June, 1941). 14 pp., illus. 2 references. British Information Services, New York. $0.75.

Floating Characteristics of a Plain and Horn-Balanced Rudder at Spinning Attitudes As Determined from Rotary Tests on a Model of a Typical Low-Wing Personal-Owner Airplane. William Bihrle, Jr. *U.S., N.A.C.A., Technical Note No. 2359*, May, 1951. 89 pp., illus. 8 references.

FLUID MECHANICS & AERODYNAMIC THEORY

Readers' Forum: The Analogy Between Irrotational Gas Flow and Minimal Surfaces. C. Truesdell. *Journal of the Aeronautical Sciences*, Vol. 18, No. 7, July, 1951, p. 502. 5 references.

Superaerodynamik; Neue Probleme der Strömungforschung im Bereich hoher Geschwindigkeiten und grosser Höhen. Walter Wuest. *Weltraumfahrt*, No. 2, April, 1951, pp. 35–39, illus. In German. Superaerodynamics; new problems of flow research at high speeds and altitudes; summary of recent experimental methods (American).

On the Propagation of Energy in Linear Conservative Waves. L. J. F. Broer. (*Delft, Technische Hogeschool, Laboratorium voor Aero- en Hydrodynamica, Mededeling No. 67.*) *Applied Scientific Research*, Vol. A2, No. 5–6, 1951, pp. 329–344. 4 references. Reprint. Analysis of when and why the rate of energy propagation in a system of waves equals the group velocity.

On the Influence of Acoustic Relaxation on Compressible Flow. L. J. F. Broer. (*Delft, Technische Hogeschool, Laboratorium voor Aero- en Hydrodynamica, Mededeling No. 69.*) *Applied Scientific Research*, Vol. 42, No. 5–6, 1951, pp. 447–468. 6 references. Reprint.

Derivation of the general properties of compressible flow from the equations of motion. Normal shock waves and steady one-dimensional flow are studied to determine the influence of relaxation on the flow.

Readers' Forum: The Combined Supersonic-Hypersonic Similarity Rule. Milton D. Van Dyke. *Journal of the Aeronautical Sciences*, Vol. 18, No. 7, July, 1951, pp. 499, 500, illus. 7 references.

Similarity rules that correlate compressible flows past slender bodies which differ from one another only by a uniform expansion or contraction of all dimensions normal to the free-stream direction.

On the Second-Order Tunnel-Wall Constriction Corrections in Two-Dimensional Compressible Flow. E. B. Flunker and Keith C. Harder. *U.S., N.A.C.A., Technical Note No. 2350*, April, 1951. 23 pp., illus. 11 references.

Solutions are obtained for the first- and second-order Prandtl-Busemann iteration equations for the flow past thin, sharp-nosed, symmetric, two-dimensional bodies in closed channels. Tunnel-wall interference coefficients are developed from these solutions.

Influence of Variable Specific Heats on the High-Speed Flow of Air. J. Kestin. *Gt. Brit., Aeronautical Research Council, Current Papers No. 33*, June 6, 1950. 24 pp., illus. 14 references. British Information Services, New York. $0.90.

Analysis of the error of assuming constant specific heat increases with increasing Mach Number in relation to the fundamental temperature-Mach Number relationship for the steady and adiabatic flow of air. Tables were constructed of the temperature variation with Mach Number and stagnation temperature based on the thermodynamic properties of air.

Note on a Class of Solutions of the Navier-Stokes Equations Representing Steady Rotationally-Symmetric Flow. G. K. Batchelor. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 4, Part 1, March, 1951, pp. 29–41, illus. 6 references.

One- and two-parameter families of solutions in which the Navier-Stokes equations for the steady flow of a viscous fluid in a semi-infinite region bounded by an infinite rotating disc reduce to ordinary differential equations in a single-position variable.

Three-Dimensional Shock-Wave Reflections. E. Migotsky and M. V. Morkovin. *Journal of the Aeronautical Sciences*, Vol. 18, No. 7, July, 1951, pp. 484–489, 504, illus. 8 references.

A principle of sweepback is developed to study three-dimensional shock-wave reflections in the absence of boundary layer and is applied locally along the intersection of the shock and the body. The practical significance of interaction phenomena and their behavior in the presence of a boundary layer are explained.

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On Two-Dimensional Flow After a Curved Stationary Shock (With Special Reference to the Problem of Detached Shock Waves). S. S. Shu. *U.S., N.A.C.A., Technical Note No. 2364,* May, 1951. 19 pp. 11 references. General theoretical analysis.

On Shock-Wave Phenomena: Waterlike Substances. R. J. Seegar and H. Polachek. *Journal of Applied Physics,* Vol. 22, No. 5, May, 1951, pp. 640–654, illus. 7 references.

Plane shock waves in waterlike substances, one-dimensional interaction in waterlike substances, one-dimensional interaction in arbitrary fluids, simple theory of regular reflection in waterlike substances, and simple theory of three-shock intersections.

On a Solution of the Nonlinear Differential Equation for Transonic Flow Past a Wave-Shaped Wall. Carl Kaplan. *U.S., N.A.C.A., Technical Note No. 2383,* June, 1951. 35 pp., illus. 4 references.

On Turbulent Fluid Motion. Max M. Munk. *Journal of the Aeronautical Sciences,* Vol. 18, No. 7, July, 1951, pp. 442–446, illus. Partial explanation of the mechanism that produces turbulence, based on a consideration of plane Couette flow and the Poiseuille flow.

Readers' Forum: On Brozko's Theory of Turbulent Flow. William Squire. *Journal of the Aeronautical Sciences,* Vol. 18, No. 7, July, 1951, pp. 502, 503, illus. 5 references. Evaluation of Brozko's rational theory of turbulent flow in which expressions were derived for the relations between the mean motion and the turbulent fluctuations.

INTERNAL FLOW

On the Problem of Gas Flow Over an Infinite Cascade Using Chaplygin's Approximation. G. A. Bugaenko. (*Prikladnaia Matematika i Mekhanika,* Moscow, Vol. 13, No. 4, 1949, pp. 449–456.) *U.S., N.A.C.A., Technical Memorandum No. 1298,* May, 1951. 16 pp., illus. 3 references. The steady flow of a compressible fluid past two-dimensional infinite cascades is obtained by using the Chaplygin simplified pressure-density relation.

Analytical Evaluation of Aerodynamic Characteristics of Turbines with Nontwisted Rotor Blades. William R. Slivka and David H. Silvern. *U.S., N.A.C.A., Technical Note No. 2365,* May, 1951. 52 pp., illus., folding charts. 4 references. Analysis of the radial variations of the velocity vectors at the stator and rotor exit; design of blade profiles to obtain the desired velocity diagrams.

An Approximate Method for the Estimation of the Design Point Efficiency of Axial Flow Turbines. D. G. Ainley. *Gt. Brit., Aeronautical Research Council, Current Papers No. 30 (Memorandum No. M.59),* 1950 (August, 1949). 24 pp., illus. 10 references. British Information Services, New York. $1.00.

Surging in Centrifugal and Axial Flow Compressors. R. O. Bullock and H. B. Finger. *S.A.E., National Aeronautic Meeting, New York, April 16–19, 1951, Preprint No. 605.* 15 pp., illus. 6 references.

General review of the problems associated with compressor surge. Compressor research was carried out by the N.A.C.A. to determine experimentally the flow characteristics during surging and general explanations of surging. Several methods of varying the surge limit are presented for the axial-flow compressor.

Possible Application of Blade Boundary-Layer Control to Improvement of Design and Off-Design Performance of Axial-Flow Turbomachines. John T. Sinnette, Jr., and George R. Costello. *U.S., N.A.C.A., Technical Note No. 2371,* May, 1951. 32 pp., illus. 14 references.

Fluctuations in a Spray Formed by Two Impinging Jets. Marcus F. Heidmann and Jack C. Humphrey. *U.S., N.A.C.A., Technical Note No. 2349,* April, 1951. 35 pp., illus. 5 references. Analysis of photographic and frequency data of the characteristics of the instability associated with the spray formed by two impinging jets.

Turbulence-Intensity Measurements in a Jet of Air Issuing from a Long Tube. Barney H. Little, Jr., and Stafford W. Wilbur. *U.S., N.A.C.A., Technical Note No. 2361,* May, 1951. 30 pp., illus. 2 references.

Investigation of a jet configuration consisting of a subsonic air jet issuing from a fully developed turbulent pipe flow and bounded by an annular jet in which the maximum velocity was equal to the mean velocity across the inner pipe at a Reynolds Number range of 2×10^4 to 12×10^4 and a velocity of 15–115 ft. per sec.

Gas Flow with Straight Transition Line. L. V. Ovsiannikov. (*Prikladnaia Matematika i Mekhanika,* Moscow, Vol. 13, 1949, pp. 537–542.) *U.S., N.A.C.A., Technical Memorandum No. 1295,* May, 1951. 13 pp., illus. 2 references.

A solution, based on Chaplygin's solutions, is obtained for the gas flow when the constant pressure in the surrounding medium is exactly equal to the critical pressure for the given initial state of the gas. The method is applied to a jet flowing out of an opening in a vessel with plane walls.

PARASITIC COMPONENTS & INTERFERENCE

Analysis of the Effects of Wing Interference on the Tail Contributions to the Rolling Derivatives. William H. Michael, Jr. *U.S., N.A.C.A., Technical Note No. 2332,* April, 1951. 37 pp., illus. 5 references.

Effect of Tail Surfaces on the Base Drag of a Body of Revolution at Mach Number of 1.5 and 2.0. J. Richard Spahr and Robert R. Dickey. *U.S., N.A.C.A., Technical Note No. 2360,* April, 1951. 25 pp., illus. 7 references.

Wind-tunnel tests at $M = 1.5$ and 2.0 to investigate the influence of rectangular tail surfaces of aspect ratio 2.33 on the base drag of an unboattailed body of revolution with a turbulent boundary layer. The variation in base pressure with axial location of the tail surfaces, the number of tail surfaces, and the airfoil thickness ratio were also studied. Tests results are compared with estimated values computed from a superposition of the airfoil-pressure field onto the base-pressure field behind the body.

PERFORMANCE

High-Speed Aerodynamic Problems of Turbojet Installations. H. Luskin and H. Klein. *American Society of Mechanical Engineers, Transactions,* Vol. 73, No. 4, May, 1951, pp. 375–384, illus. 16 references.

Performance requirements of a turbojet aircraft from an aerodynamic point of view. Engine performance is analyzed, including engine installation positions and thrust augmentation. Pressure losses are studied as a basis for correct inlet-scoop design.

Variation in Airplane Range with Wind Velocity. Robert E. Hage. *Aeronautical Engineering Review,* Vol. 10, No. 7, July, 1951, pp. 18–22, illus. 1 reference.

A nondimensional procedure for expressing range and cruise speed in terms of average airplane weights leads to simple graphic relationships of the effect of wind velocity on airplane range performance.

Some Collected Formulae for Use in Range Estimation. H. Roberts. *Gt. Brit., Aeronautical Research Council, Civil Aircraft Research Committee, Report No. 11, 953-Civ.112,* November 26, 1948. 29 pp., illus. 3 references.

Formulas for an aircraft with reciprocating engines and propellers in flight at constant C_L and altitude, constant speed and altitude, constant power and altitude; for turbojet aircraft in flight at constant C_L and altitude, constant speed and altitude, constant thrust and altitude, and constant C_L and thrust rating with varying altitude. Compressibility effects and small variations in specific fuel consumption are ignored.

STABILITY & CONTROL

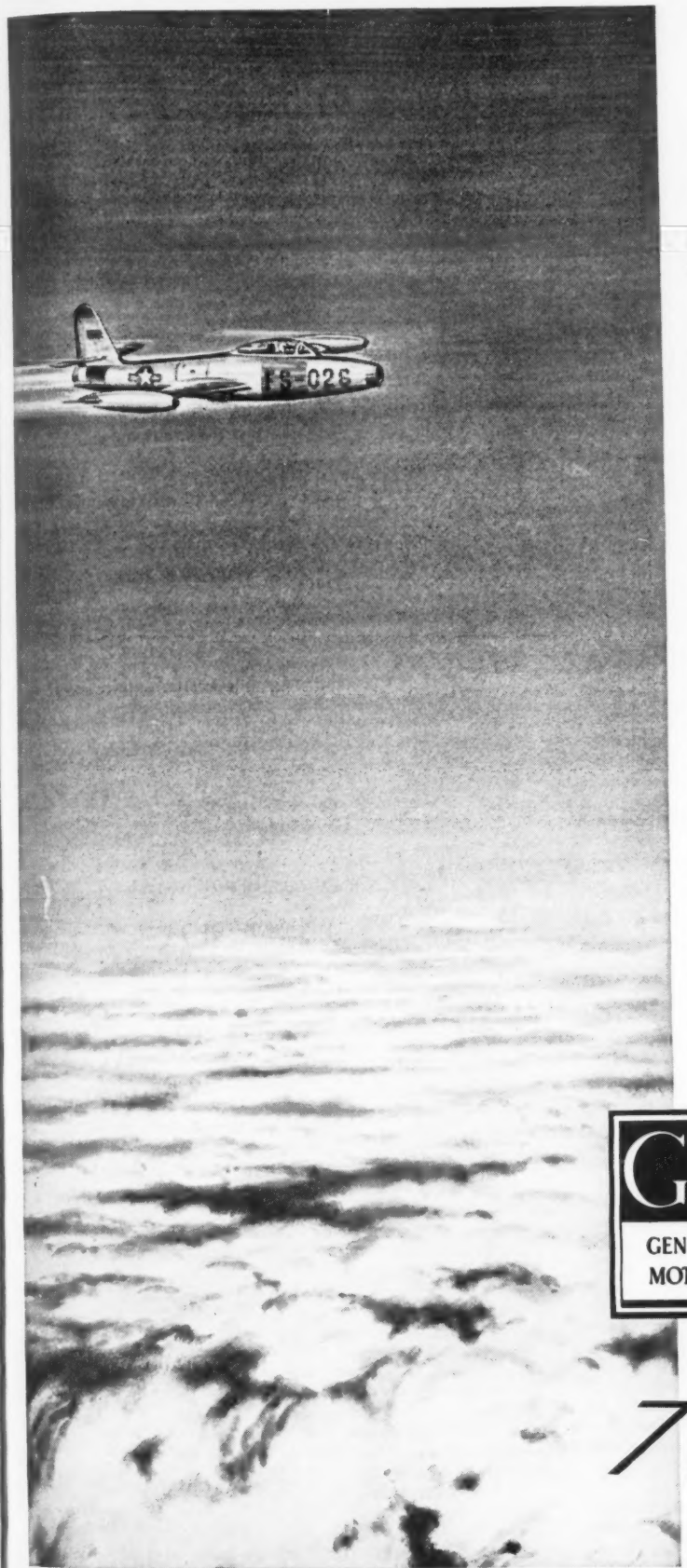
Effect of Vertical-Tail Area and Length on the Yawing Stability Characteristics of a Model Having a 45° Sweptback Wing. William Letko. *U.S., N.A.C.A., Technical Note No. 2358,* May, 1951. 49 pp., illus. 6 references.

Tests in the 6- by 6-ft. curved-flow test section of the Langley stability tunnel at $M = 0.13$ and $R = 0.71 \times 10^6$ on a 45° sweptback wing of aspect ratio 4. The effect of vertical tail area and tail length on the yawing derivatives of a high-speed-airplane configuration and interference effects were determined.

Effect of Aspect Ratio and Sweepback on the Low-Speed Lateral Control Characteristics of Untapered Low-Aspect-Ratio Wings Equipped with Retractable Ailerons. Jack Fischel and John R. Hagerman. *U.S., N.A.C.A., Technical Note No. 2347,* May, 1951. 36 pp., illus. 15 references.

Low-speed tests in the Langley 7- by 10-ft. tunnel of wings of aspect ratios 1.13, 2.13, and 4.13 with 0.60 semispan retractable ailerons at $0.70c$ and of a wing of 45° sweepback and aspect ratio of 2.09 with 0.60 semispan plain and stepped retractable ailerons at $0.70c$. Tests were made at an angle of attack range of −8° to 32°.

Spin-Tunnel Investigation of the Effects of Mass and Dimensional Variations on the Spinning Characteristics of a Low-Wing



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Single-Vertical-Tail Model Typical of Personal-Owner Airplanes. Walter J. Klinar and Jack H. Wilson. *U.S., N.A.C.A., Technical Note No. 2352*, May, 1951. 130 pp., illus. 18 references. Results of tests in the Langley 20-ft. free-spinning tunnel; analysis of these results according to C.A.A. personal aircraft requirements.

Note on Wind-Tunnel Measurements of Yawing Moment, Rudder Fixed and Free, on Models of Three Aircraft. J. E. Adamson, E. C. Brown, and R. H. Allen. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2534*, 1951 (July, 1941). 16 pp., illus. 1 reference. British Information Services, New York. $0.75. Models of Sunderland, Halifax, and Lancaster aircraft were tested in the $11\frac{1}{2}$- by $8\frac{1}{2}$-ft. R.A.E. tunnel at 122 ft. per sec. to study lateral stability characteristics.

Wind Tunnel Tests on a Griffith Meteor Model (Without Suction). D. A. Clarke. *Gt. Brit., Aeronautical Research Council, Current Papers No. 37* (*Report No. Aero.2168*), 1951 (November, 1946). 18 pp., illus. 5 references. British Information Services, New York. $0.65. Wind-tunnel tests on a 1/7.5-scale model of the Meteor with Griffith wing at Mach Numbers up to 0.2, with $R = 1.2\text{–}4.6 \times 10^6$, angle of incidence = 0° to stall, and aileron angle = 0–14°.

Low-Speed Wind Tunnel Investigation of the Change in Aerodynamic Centre Position and in C_{m_0} Due to Propeller Turbine Nacelles. D. A. Kirby and F. W. Dee. *Gt. Brit., Aeronautical Research Council, Current Papers No. 39* (*Report No. Aero.2356*), 1951 (February, 1950). 39 pp., illus. 6 references. British Information Services, New York. $1.40. Presentation and discussion of test results.

THERMOAERODYNAMICS

An Analysis of Supersonic Aerodynamic Heating with Continuous Fluid Injection. E. B. Klunker and H. Reese Ivey. *U.S., N.A.C.A., Report No. 990*, 1950. 10 pp., illus. 8 references. Superintendent of Documents, Washington. $0.15.

The steady-state heating of laminar flows is calculated at altitudes of 0–200,000 ft., $M = 5$, 10, and 15, and various surface lengths. Injecting a coolant through a porous surface into the boundary layer reduces aerodynamic heating. Heat reduction is calculated for a flat porous surface for three coolant injection rates.

WINGS & AIRFOILS

Wind Tunnel Tests on the Supermarine S.24/37, a High-Wing Monoplane with a Variable-Incidence Wing. H. Davies, J. E. Adamson, and J. Seddon. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2451*, 1951 (March, 1941). 39 pp., illus. British Information Services, New York. $1.60. Results of tests on a $\frac{1}{6}$-scale model in the R.A.E. $11\frac{1}{2}$ by $8\frac{1}{2}$-ft. tunnel to investigate characteristics associated with the variable-incidence wing.

Sur une Generalisation de la Transformation de Joukowsky. G. Couchet. *Le Recherche Aéronautique*, No. 20, March-April, 1951, p. 23, illus. In French.

Two-Dimensional Transonic Flow Past Airfoils. Yung-Huai Kuo. *U.S., N.A.C.A., Technical Note No. 2356*, May, 1951. 48 pp., illus. 4 references.

Mapping the flow about a symmetric Joukowski airfoil of small thickness by using an approximate incompressible flow rather than an exact flow. This approximate flow is derived from source-sink considerations.

Theoretical Calculation of the Downwash Factor for Unswept Trapezoidal Wings with Regard to the Compressibility for Subsonic Velocities. W. Jacobs. *Sweden, Flygtekniska Försöksanstalt, Meddelande Nr. 38*, 1950. 20 pp., illus. 9 references. Tekniska Högskolans Rotaprinttryckeri, Stockholm. Kr. 2:50.

Calculation of the downwash factor for trapezoidal wings of aspect ratios of 3, 6, 10, and 15, taper ratios of 1, 0.6, and 0.2 for various distances of the horizontal tail behind the wing. The downwash is computed for incompressible flow, and the calculations are extended to cover the influence of compressibility. Results are presented in diagrams.

Measurement of the Pressure Distribution on Rectangular Wings of Different Aspect Ratios. Olof A. M. Holme. *Sweden, Flygtekniska Försöksanstalt, Meddelande Nr. 37*, 1950. 27 pp., illus. 7 references. Tekniska Högskolans Rotaprinttryckeri, Stockholm. Kr. 3:–.

Measurements in the 3.60-m. low-speed tunnel of F.F.A. on 9.2 per cent thick symmetric rectangular wings of aspect ratios of 0.52–4.50. Test speed was 45 meters per sec. at $R = 1.8 \times 10^6$. From the test data, pressure distribution at zero incidence and at angles of attack from 0–20°, the section normal force coefficients, section center of pressure positions, wing normal force coefficient, and wing center of pressure were computed.

Investigations on Sweptback and Straight Wings at High Subsonic Speeds. Jakob Ackeret, Max Degen, and Nikolaus Rott. (*Zeitschrift für angewandte Mathematik und Physik*, Vol. 1, 1950, pp. 32–42.) *U.S., Air Force, Institute of Technology, Translation*, January, 1951. 11 pp., illus. 4 references.

Analysis of tunnel-wall effects, and methods of calculating tunnel-wall corrections to determine the influence of the tunnel on sweepback. Drag measurements were obtained on a series of geometrically similar models at the same Reynolds Number to check tunnel correction calculation. After applying corrections, straight and swept wings were compared.

Experiments on Two Piercy Aerofoils in the Compressed Air Tunnel. D. H. Williams, A. H. Bell, and W. G. Raymer. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2459*, 1950 (August 2, 1939). 25 pp., illus. 4 references. British Information Services, New York. $1.15.

Tables give test results of symmetric airfoils 12 and 20 per cent thick, with $(t/c)_{max.}$ at 0.40c. The airfoils were tested at values of R up to 7×10^6 with and without 15 per cent split flaps.

Tests on Thick Cuff Sections in the Compressed Air Tunnel. D. H. Williams and A. F. Brown. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2457*, 1951 (June 27, 1942). 8 pp., illus. British Information Services, New York. $0.50.

Tests on symmetrical 40 and 50 per cent thick airfoil sections and on a 40 per cent section with 10 per cent camber at $R = 0.3 \times 10^6$ to $R = 7.0 \times 10^6$ and angle of incidence range of $-5°$ to 30° with varying degrees of surface roughness.

The Lift and Moment Acting on a Circular-Arc Aerofoil in a Stream Bounded by a Plane Wall. S. Tomotika, K. Tamada, and H. Umemoto. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 4, Part 1, March, 1951, pp. 1–22, illus. 7 references.

The behavior of a circular-arc airfoil is investigated by means of conformal transformation, and general formulas are developed for the lift and moment. Numerical results are computed for airfoils of camber 0.022, 0.053, and 0.097 at angle of incidence of 5°.

The Effect of Non-Uniformity of the Stream on the Aerodynamic Characteristics of a Moving Aerofoil. E. E. Jones. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 4, Part 1, March, 1951, pp. 64–77. 6 references.

Development of the complex potential theory for a cylinder with motion relative to the motion of a nonuniform stream. Expressions are derived for the lift, drag, and couple acting on the cylinder. The effect of a general type of vortex wake behind the cylinder is investigated. The results are applied to determine the characteristics of a moving airfoil of small thickness and camber.

Charts and Tables for Use in Calculations of Downwash of Wings of Arbitrary Plan Form. Franklin W. Diederich. *U.S., N.A.C.A., Technical Note No. 2353*, May, 1951. 37 pp., illus., folding charts. 8 references.

Effect of Aspect Ratio on the Low-Speed Lateral Control Characteristics of Unswept Untapered Low-Aspect-Ratio Wings. Rodger L. Naeseth and William M. O'Hare. *U.S., N.A.C.A., Technical Note No. 2348*, May, 1951. 47 pp., illus. 12 references.

Wings of aspect ratios 1.13, 2.13, 4.13, and 6.13 with 0.25c sealed ailerons of various spans and spanwise locations were tested at $M = 0.26$ to determine lateral control and basic aerodynamic characteristics and lateral-stability parameters. Design charts, based on test results, are given for estimating aileron effectiveness.

A Study of Methods to Increase the Lift of Supersonic Airfoils at Low Speed. A. D. Pollock, Jr., and F. F. Peck. *California Institute of Technology, Thesis for the Professional Degree in Aeronautical Engineering*, 1947. 34 pp., illus. 10 references.

Low-speed investigation of the lift, drag, and stalling speed characteristics of a 10 per cent symmetric double-wedge airfoil tested with nose flaps, trailing-edge split flaps, and boundary-layer control. Test procedure, apparatus, and model construction are given. A sheet of high-velocity air was blown out over

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C	60-45-15	65/75000	50/60000	17.0/23.0	140/180	Annealed
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the airfoil upper surface through a spanwise slit located at 0.15c for boundary-layer studies.

Theoretical Stability Derivatives of Thin Sweptback Wings Tapered to a Point with Sweptback or Sweptforward Trailing Edges for a Limited Range of Supersonic Speeds. Frank S. Malvestuto, Jr., and Kenneth Margolis. *U.S., N.A.C.A., Report No. 971*, 1950. 14 pp., illus. 9 references. Superintendent of Documents, Washington. $0.20.

Pressure distributions, computed for the basic triangular wing, are used to determine the stability derivatives at supersonic speeds for this series of sweptback wings. The analysis is restricted to Mach Numbers at which the wings are contained within the Mach cone swinging from the apex and the trailing edge of the center section of the wing.

Measurements of the Pressure Distribution on Swept Back Wings with Trailing Edge Split Flaps; Summary of Wind Tunnel Work at the College of Aeronautics, 1948–1950. A. W. Babister. *College of Aeronautics, Cranfield, England, Report No. 43*, March, 1951. 24 pp., illus. 15 references. 5*s*. Pressure distributions on 45° sweptback untapered wings of aspect ratios 2 and 4, fitted with full- and part-span trailing-edge split flaps, at $R = 0.5 \times 10^6$.

Readers' Forum: Equivalence of the Spanwise Lift Distribution to the Spanwise Lift-Influence Function for Slender Wings and Wing Bodies. G. K. Morikawa and A. E. Puckett. *Journal of the Aeronautical Sciences*, Vol. 18, No. 7, July, 1951, pp. 503, 504, illus. 9 references.

Aeroelasticity

The Evaluation of Matrix Elements for the Analysis of Swept-Back Wing Structures by the Method of Oblique Coordinates. S. R. Lewis. *College of Aeronautics, Cranfield, England, Report No. 44*, April, 1951. 22 pp., illus. 1 reference. 5*s*.

Numerical evaluation of the matrix elements for the determination of the stresses and strains, including tables and graphs of values for common aircraft parameters; approximations of the matrix elements and percentage variation from actual calculated values.

Tables of the Theodorsen Circulation Function for Generalized Motion. Yudell L. Luke and Max A. Dengler. *Journal of the Aeronautical Sciences*, Vol. 18, No. 7, July, 1951, pp. 478–483, illus. 18 references. Tables for generalized and harmonic motion; significance of the $C(k)$ function.

An Iterative Transformation Procedure for Numerical Solution of Flutter and Similar Characteristic-Value Problems. Myron L. Gossard. *U.S., N.A.C.A., Technical Note No. 2346*, May, 1951. 75 pp., illus. 8 references.

Explanation of H. Wielandt's iterative transformation procedure; numerical examples show the application to ordinary natural-vibration problems and to flexure-torsion flutter problems.

The Effect of Torsional Flexibility on the Rolling Characteristics at Supersonic Speeds of Tapered Unswept Wings. Warren A. Tucker and Robert L. Nelson. *U.S., N.A.C.A., Report No. 972*, 1950. 28 pp., illus. 4 references. Superintendent of Documents, Washington. $0.25.

Analysis of tapered unswept wings with partial span constant-per cent-chord ailerons extending inboard of the wing tip. The procedures for calculating the aerodynamic forces and moments are based on the linearized equations for three-dimensional supersonic flow, assuming that the loads arising from aileron deflection form the principal twisting moment. Charts give the variation of the parameters with Mach Number.

Graphical Treatment of Binary Mass-Balancing Problems. R. A. Frazer. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2551*, 1951 (August 28, 1942). 10 pp., illus. 3 references. British Information Services, New York. $0.50. Classical flutter theory and known properties of test conics form a basis for a graphic test method of the effectiveness of mass balancing in flutter prevention.

The Effect of Tab Mass-Balance on Flutter. I—Ternary Tailplane-Elevator-Tab Flutter. G. H. L. Buxton and G. D. Sharpe. **II—Experiments on the Influence of Tab Mass-Balance on Flutter.** C. Scruton, P. M. Ray, and D. V. Dunsdon. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2418*, 1951 (November, 1946). 18 pp., illus. 8 references. British Information Services, New York. $0.90.

I. Analysis of the flutter characteristics of tail planes carrying elevators and tabs, considering vertical bending of the fuselage,

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elevator rotation, and tab rotation. **II.** Experiments in the N.P.L. on the flutter of a three-dimensional wing model with a part-span aileron and tab with three degrees of freedom.

The Application of the Statistical Theory of Extreme Values to Gust-Load Problems. Harry Press. *U.S., N.A.C.A., Report No. 991*, 1950. 16 pp., illus. 14 references. Superintendent of Documents, Washington. $0.20. Method of application; evaluation of the procedure in certain gust-load problems; reliability.

On the Application of Mathieu Functions in the Theory of Subsonic Compressible Flow Past Oscillating Airfoils. Eric Reissner. *U.S., N.A.C.A., Technical Note No. 2363*, May, 1951. 42 pp 9 references.

Solution, in terms of Mathieu functions, for two-dimensional flow; application to the problem of calculating three-dimensional corrections for the results of two-dimensional theory.

An Application of the Escalator Process. J. Morris. *Aircraft Engineering*, Vol. 23, No. 267, May, 1951, pp. 136, 137. 2 references.

Method of solution of quasi-Hermitian frequency equations encountered in such problems as the whirling of contrarotating propeller systems and the mechanical vibration of aircraft.

Investigation of the Structural Damping of a Full-Scale Airplane Wing. Dwight O. Fearnow. *U.S., N.A.C.A., Research Memorandum No. L51A04*, March 9, 1951. 13 pp., illus. 4 references. Apparatus, procedure, and results.

Aero Digest Scientific Review: Aeroelasticity. Robert McLarren. *Aero Digest*, Vol. 62, No. 5, May, 1951, pp. 97–108, illus. 31 references.

Air Transportation (41)

Air Transport 1949–1950, with a View to the Future. R. Dixon Speas. *SAE Journal*, Vol. 59, No. 5, May, 1951, pp. 41–44. (Excerpts from a paper.) Results of a survey of passenger and cargo users; current status of transport aircraft and of the aircraft industry in general; outlook.

Overhead and Floor Tow Conveyors for Air Cargo. J. C. Webb. *American Society of Mechanical Engineers, Annual Meeting, November 26–December 1, 1950, Paper No. 50-A-132.* 10 pp., illus. Mechanization and operation of towing conveyors for sorting and distributing cargo to trucks and for handling the cargo from the aircraft to the terminal building.

United States Overseas Air Cargo Services. XIV—Improvements Needed and Problems Requiring Solution. N. W. Kendall. *Air Transportation*, Vol. 18, No. 5, May, 1951, pp. 10, 31–34. Consideration of rate reductions, service improvements, and trade and exchange controls.

Operating Cost Characteristics of Local Air Service Operators. Charles W. Wendt. *S.A.E., National Aeronautic Meeting, April 16–19, 1951, Preprint No. 610.* 8 pp., map.

The Influence of Bilateral Agreements, Tariffs, and Subsidies on International Air Transport. George Gribbett. *Aeronautical Society of India, Journal*, Vol. 3, No. 1, February, 1951, pp. 1–11.

Airplane Design (10)

Planning and Aircraft Development. F. Olaf Thornton. *Royal Aeronautical Society, Journal*, Vol. 55, No. 485, May, 1951, pp. 303–322, illus.

Planning procedures are applied to the design development of a prototype aircraft; the planning covers the period from the initial design proposal up to the first flight. Methods, including charts, are presented for estimating development time, manpower needed, costs, and effect of design changes.

Characteristics of Military Cargo Aircraft Past, Present, and Future. L. S. Rochte. *American Society of Mechanical Engineers, Annual Meeting, November 26–December 1, 1950, Paper No. 50-A-134.* 6 pp., illus.

Treatise on Experience; Review of Some Detail Design Experiences. W. W. Davies. *S.A.E., National Aeronautic Meeting, April 16–19, 1951, Preprint No. 608.* 16 pp., illus. Some typical cases of failure of aircraft and equipment due to faulty design and manufacturing techniques.

Operational Experiences with Multi-Engine Jet Aircraft. N. N. Davis and E. M. Beattie. *S.A.E., National Aeronautic Meeting, April 16–19, 1951, Preprint No. 618.* 11 pp., illus. Opinions on performance of jet aircraft, drawn from the General Electric flight-test program using a North American B-45-C equipped with four J-47 turbojet engines.

Review of Developments in Landing Speed Reduction and Hovering Aircraft. David H. Kaplan. *The Daniel & Florence Guggenheim Aviation Safety Center at Cornell University*, 2 East 64th Street, New York 21, N.Y., May, 1951. 8 pp. 74 references. $0.25.

Brief summary of progress; research on boundary-layer control, utilization of propeller slipstream, and flap and slot devices for reducing landing speed; aircraft design studies on ornithopters, Magnus effect aircraft, gyrodynes, and convertiplanes.

AIRPLANE DESCRIPTIONS

Britain's Turbine Aircraft; Their Development and Present Status. *Flight*, Vol. 59, No. 2207, May 11, 1951, pp. 553–558, illus. Research, military and civil types.

British Naval Aircraft; Past and Present Types for Fighting, Reconnaissance, and Attack. *Flight*, Vol. 59, No. 2204, April 20, 1951, pp. 474–476, illus.

Aero Commander 520 High-Wing Twin-Engined 5-Place Airplane. *American Aviation*, Vol. 14, No. 45, May 28, 1951, pp. 21, 23, illus. *Flight Magazine*, Vol. 35, No. 5, May, 1951, p. 18–20, 36, 38, 40, 41, illus. Production procedure and equipment.

Boeing B-47 Stratojet Six-Engined Turbojet Bomber. Robert M. Robbins and William H. Cook. *S.A.E., National Aeronautic Meeting, April 16–19, 1951, Preprint No. 617.* 8 pp., illus. Flight characteristics.

Boeing C-97A Stratofreighter Four-Engined Military Transport (Versatility plus Performance). Alan F. Kelsey. *American Society of Mechanical Engineers, Annual Meeting, November 26–December 1, 1950, Paper No. 50-A-142.* 13 pp., illus. Commercial and military uses; cargo loading and handling.

de Havilland D. H. 106 Comet Four-Engined Turbojet Transport, England. H. Povey. *The Aeroplane*, Vol. 80, No. 2075, April 27, 1951, pp. 510–513, illus. *Flight*, Vol. 58, No. 2205, April 27, 1941, pp. 500–503, illus. (Summaries of an R.Ae.S. lecture, April 12, 1951: Planning and Production Methods Used in the Construction of the de Havilland Comet.)

Douglas Super DC-3 Twin-Engined Transport. *American Aviation*, Vol. 14, No. 45, May 28, 1951, pp. 24, 25, illus. Results of Capital Airlines' use of the Super DC-3 for 5,000 hours of scheduled operations; maintenance problems; economics.

LA-17 Single-Engined Turbojet Fighter, U.S.S.R. Chalmers H. "Slick" Goodlin. *Aviation Age*, Vol. 15, No. 5, May, 1951, pp. 21, 22, illus., cutaway drawing.

Percival P.56 Single-Engined Basic Trainer, England. *The Aeroplane*, Vol. 80, No. 2076, May 4, 1951, pp. 536–542, illus., cutaway drawings. *Flight*, Vol. 59, No. 2206, May 4, 1951, pp. 527–533, illus., cutaway drawings.

Short Sturgeon T.T. Mark II Twin-Engined Carrier-Based Target-Towing Airplane, England. *The Aeroplane*, Vol. 80, No. 2075, April 27, 1951, pp. 506–509, illus.

CONTROL SYSTEMS

New Gust Alleviator Will Help Lighten Plane Structures; Increased Speed Range Expected to Result. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 16, No. 6, June, 1951, p. 5, illus.

Development of a gust alleviator that is a mechanical linkage hooked up to the plane's ailerons. The device, developed by the Air Force and Douglas Aircraft Company, Inc., relieves the effects of the vertical motion caused by gusts.

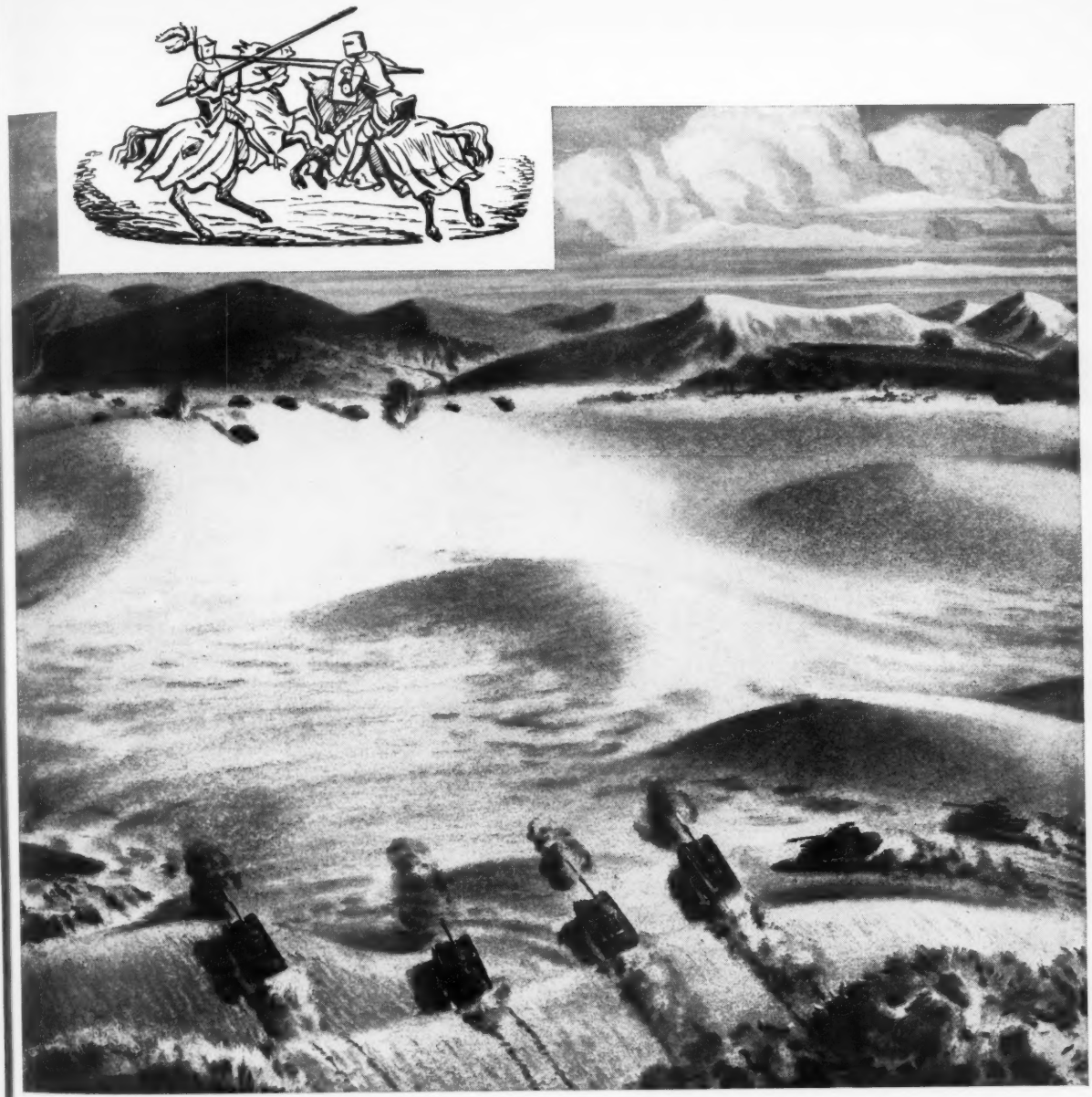
FUEL TANKS

An Investigation of the Crash-Fire Problems in Transport Aircraft Fuel Tanks. R. L. Field, Melvin F. Miller, and George L. Pigman. *U.S., Civil Aeronautics Administration, Technical Development Report No. 134*, January, 1951. 21 pp., illus.

LANDING GEAR

Aircraft Ski Research in Canada. G. J. Klein. *Canada, National Research Laboratories, Division of Mechanical Engineering, Engineering Section, Report No. MM-225*, August 15, 1950. 31 pp., illus. 19 references. General account of the various phases of Canadian ski research; design trends; results of ski trials with the de Havilland Beaver.

Landing Gear; Shock Absorbers and Drop Testing. I—Shock Absorbers. John F. Ceccarelli. *Hydraulic Engineer*, Vol. 1, No. 1, April-May, 1951, pp. 4, 5, illus.



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Airports & Airways (39)

Esso Hydrant Refueling Systems. Andrew D. Lewis. *Esso Air World*, Vol. 3, No. 5, March-April, 1951, pp. 131–133, illus. Operation of the gravity, remote-control pressure, and automatic Pressuretol types of hydrant refueling systems. Examples show installations at major airports.

Perspective Analysis of the Proposed ALPA Approach Light System. *U.S., Civil Aeronautics Administration, Technical Development Report No. 133 (Supplement to Technical Development Report No. 96)*, January, 1951. 15 pp., illus. 1 reference.

A Study of Runway Markings. S. J. Gerathewohl, H. Haber, Victor A. Byrnes, P. H. Ripple, and W. M. Patterson. *U.S., Air Force, School of Aviation Medicine, Randolph Field, Texas, Project No. 21-24-001, Report No. 4*, January, 1951. 22 pp., illus., folding chart.

Aviation Medicine (19)

Observations on Disturbances of Equilibrium and Other Symptoms by Jet Engine Noise. E. D. D. Dickson and D. L. Chadwick. *Gt. Brit., Royal Air Force, Flying Personnel Research Committee, Report No. 746*, November, 1950. 13 pp., illus. 17 references. Survey of ground personnel working on jet engines to determine if noise of sonic and ultrasonic frequencies caused physical disturbances.

The Effects of Time and Temperature Upon Tolerance to Positive Acceleration. Ernest E. Martin and James P. Henry. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 16, No. 6, June, 1951, pp. 19–23, illus.

Results of tests in the Air Research and Development Command Human Centrifuge. Tests were run on eleven subjects, with and without the U.S.A.F. G-4A anti-G suit; duration time of tests, 15 sec. and 2 min. at accelerations up to 4.5 g.

Activities of the Vascular System During Hypoxia. I—The Activity of the Spleen in Hypoxia. Kurt Kramer and Ulrich C. Luft. *U.S., Air Force, School of Aviation Medicine, Randolph Field, Texas, Project No. 21-23-013, Report No. 1*, December, 1950. 18 pp., illus. 25 references.

Studies on Effects of Windshields and/or Air of Different Densities on Stereoscopic Vision. II—Description of a Stereo-Meter and Method for Measuring Cyclo-Incongruities. Paul A. Cibis, Mathew R. Wilson, and Horst G. Fleck. *U.S., Air Force, School of Aviation Medicine, Randolph Field, Texas, Unnumbered Project, Report No. 2*, November, 1950. 23 pp., illus. 14 references.

The Effect of Retinal Illumination on Visual Perception of Space. I—Experimental Studies Related to a Special Type of Aniseikonia. Paul A. Cibis. *U.S., Air Force, School of Aviation Medicine, Randolph Field, Texas, Project Number 21-31-011, Report No. 1*, March, 1951. 28 pp., illus. 60 references.

Critical Flicker Frequency and Aerial Stress; Memorandum Report. Ernest L. McCollum. *U.S., Air Force, Arctic Aero Medical Laboratory, Ladd Air Force Base, Alaska, Special Report*, February, 1951. 7 pp., 11 references.

Intermittent Loud Noise and Mental Performance. Kendon R. Smith. *U.S., Air Force, Technical Report No. 6368*, December, 1950. 8 pp., illus. 4 references.

Cockpit Lighting: A General Survey of the Principles and Techniques, with Particular Reference to the Development of the Dual System. E. S. Calvert. *Gt. Brit., Aeronautical Research Council, Current Papers No. 36*, 1951 (1946). 40 pp., illus. 16 references. British Information Services, New York. $1.25.

Properties of the dark-adapted eye and rules derived from them; geometric relationships necessary in a cockpit to prevent reflections and to permit cockpit illumination by a system of direct lighting (such as the Dual System); methods of cockpit lighting.

Visual Performance As a Function of Low Photopic Brightness Levels. Milton L. Rock. *U.S., Air Force, Technical Report No. 6013*, November, 1950. 31 pp., illus. 75 references.

Development of Standardized Procedures for Defining the Requirements of Aircrew Jobs in Terms of Testable Traits. Ralph F. Wagner. *U.S., Air Force, School of Aviation Medicine, Randolph Field, Texas, Project No. 21-29-010, Final Report*, January, 1951. 94 pp., illus.

Personnel Selection and Classification Procedures: Spatial Tests; A Factorial Analysis. Merrill F. Roff. *U.S., Air Force, School of Aviation Medicine, Randolph Field, Texas, Project No. 21-29-002, Final Report*, January, 1951. 46 pp., illus., folding charts.

Surveys of the Heights and Weights of Royal Air Force Personnel. V—Heights and Weights of Flying Personnel of the Royal Air Force and Commonwealth Air Forces. G. M. Morant. *Gt. Brit., Royal Air Force, Flying Personnel Research Committee, Report No. 711 (d)*, January, 1951. 26 pp., illus. 1 reference.

Evaluation of the K-S Disposable Oxygen Mask. Ulrich C. Luft, Samuel G. Karst, and Loy D. Wilson. *U.S., Air Force, School of Aviation Medicine, Randolph Field, Texas, Special Project*, January, 1951. 11 pp., illus. 4 references.

Sustenance Kit, Hot Climate, Seat Style, Individual. Norman K. Hanselman. *U.S., Air Force, Air Materiel Command, Engineering Division, Aero Medical Laboratory, Memorandum Report No. MCREXD-670-20J*, January 26, 1951. 10 pp. illus.

Man and the Machine. *Aeronautics*, Vol. 24, No. 4, May, 1951, pp. 40–43, illus. Account of the work being done at the Institute of Aviation Medicine, Farnborough.

Comfortization (23)

Seat-Manufacture. II—Design Variations; Single-Passenger Chair Manufacture; Machine Pipe-Bending. L. G. Burnard. *Aircraft Production*, Vol. 13, No. 151, May, 1951, pp. 147–153, illus. 1 reference.

General Aspects of Cabin Pressurization. R. W. Rummel. *Aeronautical Engineering Review*, Vol. 10, No. 7, July, 1951, pp. 14–17, 32, illus. Summary of T.W.A. operation of pressurized aircraft; requirements for future aircraft.

Education & Training (38)

Human Engineering Problems in Training Devices. Lynn S. Beals, Jr. *Military Surgeon*, Vol. 108, No. 5, May, 1951, pp. 417–420.

The Effects of Inserted Questions and Statements on Film Learning (Rapid Mass Learning). Albert K. Kurtz, Jeanette S. Walter, and Henry Brenner. (The Pennsylvania State College, Instructional Film Research Program.) *U.S., Office of Naval Research, Special Devices Center, Technical Report No. SDC 269-7-18*, September, 1950. 5 references.

Effects on Training of Experimental Film Variables, Study I: Verbalization, Rate of Development, Nomenclature, Errors, "How It Works," Repetition (Rapid Mass Learning). Nathan Jaspen. (The Pennsylvania State College, Instructional Film Research Program.) *U.S., Office of Naval Research, Special Devices Center, Technical Report No. SDC 269-7-17*, October, 1950. 25 pp., illus. 5 references.

The Film Analyzer (Rapid Mass Learning). C. T. Carpenter, R. C. Eggleton, F. T. John, and J. B. Cannon, Jr. (The Pennsylvania State College, Instructional Film Research Program.) *U.S., Office of Naval Research, Special Devices Center, Technical Report No. SDC 269-7-15*, October, 1950. 17 pp., illus. 1 reference.

The Classroom Communicator (Rapid Mass Learning). C. T. Carpenter, R. C. Eggleton, F. T. John, and J. B. Cannon, Jr. (The Pennsylvania State College, Instructional Film Research Program.) *U.S., Office of Naval Research, Special Devices Center, Technical Report No. SDC 269-7-14*, October, 1950. 30 pp., illus. 1 reference.

Comparison of the Audio and Video Elements of Instructional Films (Rapid Mass Learning). Harold E. Nelson, K. R. Moll, and N. Jaspen. (The Pennsylvania State College, Instructional Film Research Program.) *U.S., Office of Naval Research, Special Devices Center, Technical Report No. SDC 269-7-18*, November, 1950. 16 pp.

Electronics (3)

Estimating Temperature Rise in Electronic Equipment Cases. R. J. Bibbero. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 5, May, 1951, pp. 504–508, illus. 7 references.

Charts derived from theoretical and experimental heat-transfer coefficients are used for estimating average temperature rise of electronic equipment on the ground and in aircraft. Corrections are included for pressure, altitude, effects of case color, aircraft skin temperature, and conduction.

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Standards on Electroacoustics: Definition of Terms, 1951 (Standard 51 IRE 6. S1). *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 5, May, 1951, pp. 509–532.

ANTENNAS

An Automatic Antenna-Tuning Unit. V. True. *U.S., Naval Research Laboratory, Washington, Report No. 3755*, November 2, 1950. 14 pp., illus.

Design of an antenna-tuning system to match automatically the input impedance of a 35-ft. whip antenna to a 50-ohm coaxial transmission line over the frequency range of 2–18 mc. to operate with a TCK (400-watt output) transmitter.

Recording Antenna Radiation Patterns. Charles W. Brasse, Jr. *Radio & Television News*, Vol. 45, No. 5 (*Radio-Electronic Engineering*, Vol. 16, No. 5), May, 1951, pp. 8A–10A, illus.

The Bendix Automatic Antenna Pattern Recorder continuously plots the strength of the signal received by the antenna vs. its angular rotation. The instrument includes a 1,000-cycle amplifier and the Bendix Logarithmic Attenuator. Complete schematic diagrams show the preamplifier and postamplifier systems and the logarithmic attenuator portion of the receiver.

Slot Antenna Developments. I, II. D. R. Rhodes. *Radio & Television News*, Vol. 45, Nos. 5, 6 (*Radio-Electronic Engineering*, Vol. 16, Nos. 5, 6), May, June, 1951, pp. 3A–5A, 31A; 7–9, 29, 30; illus. 13 references.

Techniques for Handling Elliptically Polarized Waves with Special Reference to Antennas. Introduction. H. G. Booker. **I—Transmission Between Elliptically Polarized Antennas.** V. H. Rumsey. **II—Geometrical Representation of the Polarization of a Plane Electromagnetic Wave.** G. A. Deschamps. **III—Elliptically Polarized Waves and Antennas.** M. L. Kales. **IV—Measurements on Elliptically Polarized Antennas.** J. I. Bohnert. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 5, May, 1951, pp. 533–552, illus. 12 references.

Radiation Properties of Spherical Antennas As a Function of the Location of the Driving Force. Philip R. Karr. (*Ph.D. Thesis, Catholic University of America.*) *U.S., National Bureau of Standards, Journal of Research*, Vol. 46, No. 5, May, 1951, pp. 422–436, illus. 13 references. (Also available as *Research Paper No. 2211*. Superintendent of Documents, Washington. $0.10.)

Synthesis and Analysis of Elliptic Polarization Loci in Terms of Space-Quadrature Sinusoidal Components. Millett G. Morgan and W. Raymond Evans, Jr. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 5, May, 1951, pp. 552–556, illus. 8 references.

On the Diffraction of a Plane Electromagnetic Wave by a Paraboloid of Revolution. C. W. Horton and F. C. Karal, Jr. *Journal of Applied Physics*, Vol. 22, No. 5, May, 1951, pp. 575–581, illus. 9 references.

CIRCUITS & CIRCUIT ELEMENTS

Modified Wallman Circuit with Voltage Feedback. Shigeo Shimizu. *Electronics*, Vol. 24, No. 6, June, 1951, pp. 208, 210, 212, illus. Design of a new low-noise amplifier circuit in which the second stage of the Wallman circuit is replaced by a voltage-feedback amplifier.

A General-Purpose Remote Control System for Radio Transmitters. V. J. Tyler. *Marconi Review*, Vol. 15, No. 101, 2nd Quarter, 1951, pp. 61–81, illus.

Predicting Performance of UHF and SHF Systems. E. A. Slusser. *Electronics*, Vol. 24, No. 6, June, 1951, pp. 116–121, illus.

Nomograms and calculation procedure for determining the suitability of a location for U.H.F. and S.H.F. systems. Free-space attenuation, topology, atmospheric conditions, and absorption factors are included in the calculations.

A High-Stability Directly-Calibrated Oscillator. G. L. Grisdale. *Marconi Review*, Vol. 15, No. 101, 2nd Quarter, 1951, pp. 89–96, illus. 3 references.

An oscillator covering 2–4 mc. has been produced for the HR.91 series of receivers. It is hermetically sealed and has a frequency-temperature coefficient less than 5 parts in 10^6 per degree C. A direct reading frequency scale gives a tuning accuracy of ±1 kc., and the frequency changes less than 1 part in 10^6 for a 1 per cent change of high or low voltage.

A Method of Gating for Parallel Computers. A. G. Ratz and V. G. Smith. *Electrical Engineering*, Vol. 70, No. 5, May, 1951, p. 424, illus. The gate uses two diodes per flip-flop, coupling the plates of each master register to the grids of the corresponding slave register. The gating operation is done by direct coupling.

Differential Analyzer Uses Plug-In Units. C. D. Morrill. *Electronics*, Vol. 24, No. 6, June, 1951, pp. 222, 224, 226, 228, 230, illus. The Goodyear Electronic Differential Analyzer GEDA uses plug-in type multiplier units; a set of components can be easily arranged for a set of specific conditions.

Pulse-Width Discriminator. A. A. Gerlach and D. S. Schover. *Electronics*, Vol. 24, No. 6, June, 1951, pp. 105–107, illus.

Design of a pulse-width discriminator that handles pulses in the range of 20 to 100 microsec. wide. The unit was designed for intelligence-channel decoders in a multiplex communication system.

Improved Pulse Stretcher. James F. Craib. *Electronics*, Vol. 24, No. 6, June, 1951, pp. 129–131, illus.

Duration of pulses is increased as much as 25 times, with output amplitude remaining proportional to input. Flat-topped output is provided by a delay line charged by crystal rectifiers driven by a cathode follower. Sample design equations are given.

Multi-Channel Measurement of Physical Effects by Confluent Pulse Technique, with Particular Reference to the Analysis of Strain. J. G. Yates, D. H. Lucas, and D. L. Johnston. (*I.E.E., Measurements Section, Paper No. 1032.*) *Institution of Electrical Engineers, Proceedings, Part II, Power Engineering*, Vol. 98, No. 62, April, 1951, pp. 109–121, Discussion, pp. 121–124, illus. 9 references.

Measurement in impedance bridges by pulse excitation. The change in impedance is produced by a 4-arm bridge circuit. Typical bridge circuits and the pulse technique are explained. Circuit diagrams show the components and arrangement of a 10-channel strain-gage indicator; strain-gage results are recorded from a cathode-ray tube.

COMMUNICATIONS

Audio Problems in Aircraft Communication. I. H. Bowker. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 16, No. 6, June, 1951, pp. 15–19, illus.

Study of the effects of altitude on speaking ability and microphone and earphone performance, speech-to-noise discrimination in microphones, noise insulation in earphones, and electric and acoustic characteristics of the system.

The Single-Sideband System of High Frequency Radio Transmission. E. T. Wrathall and C. P. Beanland. *Marconi Review*, Vol. 14, No. 100, 1st Quarter, 1951, pp. 2–22, illus.

Definition of terms, general technical considerations (advantages and limitations of the system, practical results), two-channel system, comparison of single- and double-channel systems; design and operation of the transmitter and receiver.

NBS Develops Tiny Range Receiver. *Aviation Week*, Vol. 54, No. 19, May 7, 1951, pp. 38, 39, illus.

Low-frequency 12-tube hermetically sealed unit. The receiver has continuous tuning from 190 to 550 kc., power output of 100 mw., and a 5-microv. sensitivity for a 6-db. signal-to-noise ratio.

Design of an Apparatus for Speech Stretching. G. T. Gould, Jr. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 16, No. 5, May, 1951, pp. 14–19, illus. 1 reference.

Design details of a Speech Stretcher that permits time stretching of sound recordings by a factor of two, without altering the invariant speech characteristics. The apparatus operates on the concept of doubling all the frequency components and regaining the original frequencies by a $^1/_2$-speed playback. Some pitch alteration does take place.

COMPONENTS

Pyrolytic Film Resistors: Carbon and Borocarbon. R. O. Grisdale, A. C. Pfister, and W. van Roosebroeck. *Bell System Technical Journal*, Vol. 30, No. 2, April, 1951, pp. 271–314, illus. 32 references.

A High-Temperature Adhesive Tape Resistor. *U.S., National Bureau of Standards, Technical Report No. 1540*, May, 1951. 7 pp.

The N.B.S. tape resistor operates at temperatures up to 200°C.; its electrical characteristics are similar to those of film-type carbon resistors. The resistor consists of a mixture of graphite or carbon black, silicone resin, and solvent applied thinly to a thin roll of asbestos paper tape. It can be applied to glass or ceramic-base materials.

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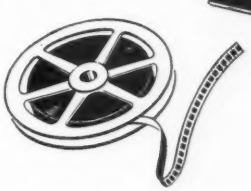

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Dielectrics Made to Order. Arthur R. von Hippel. *Electronics*, Vol. 24, No. 6, June, 1951, pp. 126–128, illus. Research work at the M.I.T. Laboratory for Insulation Research on the synthesis of materials with prescribed electric and magnetic properties and the nature of dielectric breakdown.

This Business of Testing Plastics. IV—Dielectric Strength. Charles R. Stock. *Plastics Newsfront*, Vol. 6, No. 2, April, 1951, pp. 13–15, 23, illus.

Dielectric Materials for Electrical Connectors. Harry M. Neben. *Aero Digest*, Vol. 62, No. 5, May, 1951, pp. 31, 32, 34, 38, illus. Characteristics of current dielectrics; selection factors.

Duality As a Guide in Transistor Circuit Design. R. L. Wallace, Jr., and G. Raisbeck. *Bell System Technical Journal*, Vol. 30, No. 2, April, 1951, pp. 381–417, illus. 6 references.

Letters to the Editor: Effect of Auxiliary Current on Transistor Operation. H. J. Reich, P. M. Schultheiss, J. G. Skalnik, T. Flynn, and J. E. Gibson. *Journal of Applied Physics*, Vol. 22, No. 5, May, 1951, pp. 682, 683, illus.

Fixed Capacitors for Electronic Circuits. Philip S. Schmidt. *Electrical Manufacturing*, Vol. 47, No. 5, May, 1951, pp. 101–105, 244, 246, 248, illus. 9 references. Trends in capacitor developments; new materials and manufacturing techniques; factors influencing nominal capacitance values; role of synthesis.

Structure and Properties of Ferrites. F. G. Brockman. *Electrical Engineering*, Vol. 70, No. 6, June, 1951, pp. 489–494, illus. 10 references.

High Saturation Magnetic Alloy with a Rectangular Hysteresis Loop. J. F. Libsch and Everhard Both. *Electrical Engineering*, Vol. 70, No. 5, May, 1951, pp. 420, 421, illus. 2 references. Deltamax, Hipernik V, Orthonik, and Permeron grain-oriented 50 per cent nickel-iron alloys.

Small Transformers and Chokes. I—Transformers. D. G. Stevenson. *Muirhead Technique*, Vol. 5, No. 1, January, 1951, pp. 3–6, illus. 2 references. Design of small transformers for varying requirements.

Some Practical Equivalent Circuits for Multi-Circuit Transformers. David Morris. (*I.E.E., Supply Section, Paper No. 1098.*) *Institution of Electrical Engineers, Proceedings, Part II, Power Engineering*, Vol. 98, No. 62, April, 1951, pp. 256–261, illus. 11 references.

Magslip Resolver No. 2 Type E-24-C. J. Bell. *Muirhead Technique*, Vol. 5, No. 1, January, 1951, pp. 7, 8, illus. Methods by which a voltage accuracy of 0.1 per cent has been attained.

Piezo-Electric Crystal Devices. III. S. Kelly. *Electronic Engineering*, Vol. 23, No. 279, May, 1951, pp. 173–176, illus. 7 references. Auxiliary apparatus; vibration pickups.

Zero Temperature Coefficient Quartz Crystals for Very High Temperatures. W. P. Mason. *Bell System Technical Journal*, Vol. 30, No. 2, April, 1951, pp. 366–379, illus. 3 references. Up to 200°C.

The Electric Tunnel Effect Across Thin Insulator Films in Contacts. Ragnar Holm. *Journal of Applied Physics*, Vol. 22, No. 5, May, 1951, pp. 569–574, illus. 14 references.

Effect of Fungus Growth on the Tensile Strength of Pressure-Sensitive Electrical Insulating Tapes. Sigmund Berk and Leonard Teitell. *American Society for Testing Materials, Bulletin*, No. 174, May, 1951, pp. 67–71, illus. 12 references.

CONSTRUCTION TECHNIQUES

The Stamped Circuit Process. Herbert Chase. *Radio & Television News*, Vol. 45, No. 6 (*Radio-Electronic Engineering*, Vol. 16, No. 6), June, 1951, pp. 13–15, 30, 31, illus. Construction-procedures developed by the Franklin Airloop Corp.; the stamping technique; lowered labor costs and compact assemblies.

ELECTRON TUBES

Concerning the Reliability of Electron Tubes. Marcus A. Acheson and Eleanor M. McElwee. *Sylvania Technologist*, Vol. 4, No. 2, April, 1951, pp. 38–40, illus. 1 reference.

Reliability in Miniature and Subminiature Tubes. P. T. Weeks. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 5, May, 1951, pp. 499–503, illus.

Correspondence: The Subminiature Tube—A Material Saver. Eleanor M. McElwee. *Sylvania Technologist*, Vol. 4, No. 2, April, 1951, p. 44. Table shows material savings achieved by tube miniaturization.

Elements of Thermionics. W. E. Danforth. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 5, May, 1951, pp. 485–499, illus. 5 references.

Thoria As a Cathode Emitter. W. E. Danforth. *Franklin Institute, Journal*, Vol. 251, No. 5, May, 1951, pp. 515–520, illus. 3 references.

The Rotating Beam Method for Investigation Electron Lenses. D. E. George, R. G. E. Hutter, and M. Cooperstein. *Sylvania Technologist*, Vol. 4, No. 2, April, 1951, pp. 41–43, illus. 6 references.

The Improved Ramberg Vacuum Tube Accelerometer. *Aero Digest*, Vol. 62, No. 5, May, 1951, pp. 44, 46, 94, illus.

Improvements, including stops to limit plate motion, support rods to increase the sensitivity, and a second getter, provide for a greater range of acceleration measurement, high output voltages, and damping of natural frequency responses.

Low-Noise Measurement of Tubes for Infrared Applications. P. J. Daly. *U.S., Naval Research Laboratory, Washington, Report No. 3747*, September 15, 1950. 11 pp., illus. 1 reference. Evaluation of commercial tubes (5691, 12AY7, 6SJ7, and 1620) to determine their low noise characteristics; test apparatus.

MEASUREMENTS & TESTING

Techniques of Microwave Impedance Measurement by Reflection-Coefficient Methods. P. A. Portmann. *U.S., Naval Research Laboratory, Washington, Report No. 3739*, October 4, 1950. 13 pp., illus. 4 references.

Investigation of the general features and techniques for the design of fully automatic impedance measuring and recording equipment. Reflection coefficients are indicated as a function of the frequency or load adjustments. A laboratory instrument for measuring microwave impedance in the x-band was built, and its performance was evaluated.

R.F. Micropotentiometers. *Radio & Television News*, Vol. 45, No. 5 (*Radio-Electronic Engineering*, Vol. 16, No. 5), May, 1951, p. 20A, illus. A low impedance device, developed by N.B.S. engineers, to provide accurate r.f. voltages from 1 to 10^5 microvolts.

Development Work on Two Signal Generators for the Range of 3,650 to 10,900 Mc. E. W. Weimer and R. H. Snider. *U.S., Naval Research Laboratory, Washington, Report No. 3728*, September 1, 1950. 51 pp., illus. 7 references.

A Reactance Tube Circuit for Measuring Purposes Applicable to Microphone Calibration. Henning E. von Gierke and Wolf W. von Wittern. *U.S., Air Force, Aero Medical Laboratory, Technical Report No. 6361*, January, 1951. 9 pp., illus. 5 references.

Compensation of A-C Instruments for Variation in Frequency. J. H. Miller. *Electrical Engineering*, Vol. 70, No. 6, June, 1951, pp. 494–497, illus. 5 references.

Frequency Standardization. L. Essen. (*I.E.E., Measurements Section, Paper No. 1061.*) *Institution of Electrical Engineers, Proceedings, Part II, Power Engineering*, Vol. 98, No. 62, April, 1951, pp. 154–164, Discussion, pp. 164–172, illus. 42 references. Development of present practice and standards; methods of determining frequency; calibration.

The Determination of Time and Frequency. Humphrey M. Smith. (*I.E.E., Measurements Section, Paper No. 1054.*) *Institution of Electrical Engineers, Proceedings, Part II, Power Engineering*, Vol. 98, No. 62, April, 1951, pp. 143–153, Discussion, pp. 164–172, illus. 12 references. Review of the principles involved in the astronomical determination of time; standards of accuracy; time bases for frequency measurements.

NAVIGATION AIDS

The Common System As Viewed by the Airline Operator. Leslie O. Barnes. *Talk delivered before the Airport Operators Council Fourth Annual Conference, Memphis, Tenn.*, April 19, 1951. 12 pp.

NOISE & INTERFERENCE

The Rectification and Observation of Signals in the Presence of Noise. R. E. Burgess. *Philosophical Magazine*, Vol. 42 (7th Series), No. 328, May, 1951, pp. 475–503, illus. 2 references.

Analysis of the rectification of a mixture of signal and noise by linear and square-law detectors; comparison of results with previous works. The formulas developed are applied to the evalua-

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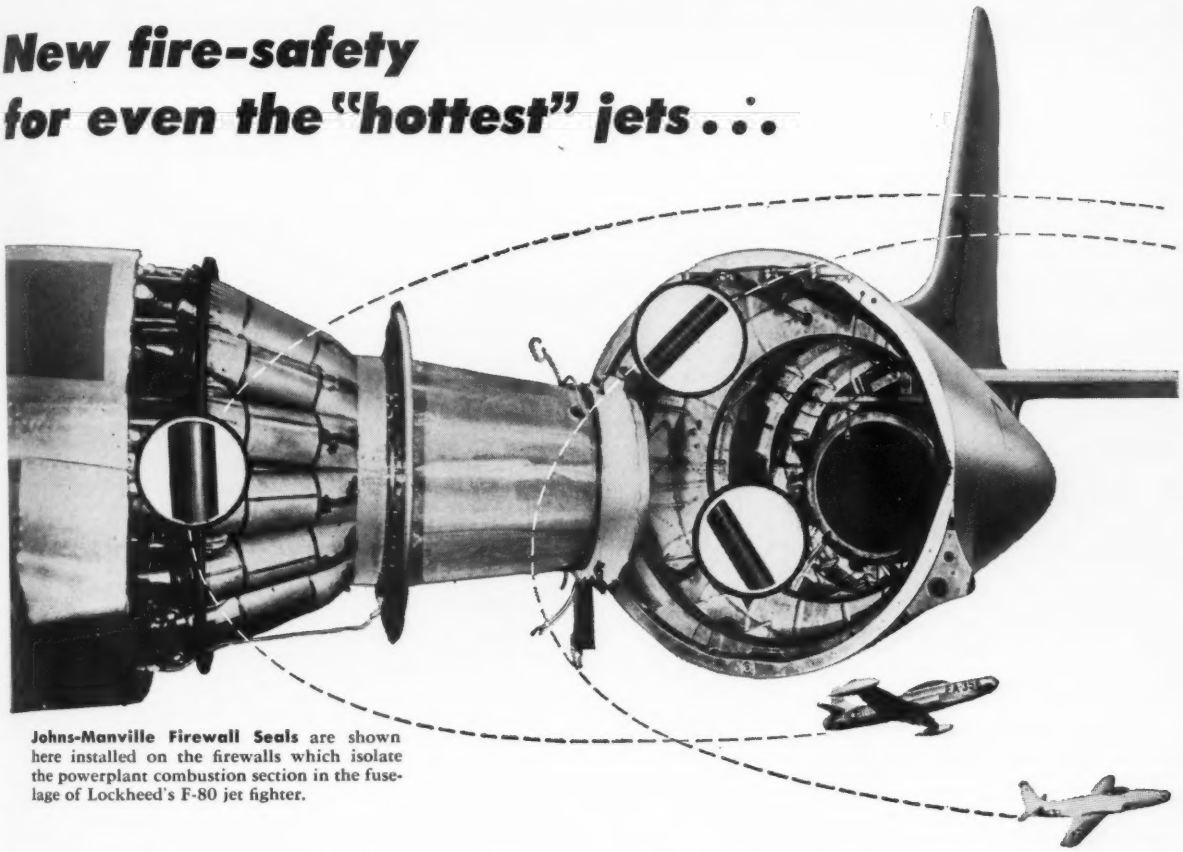

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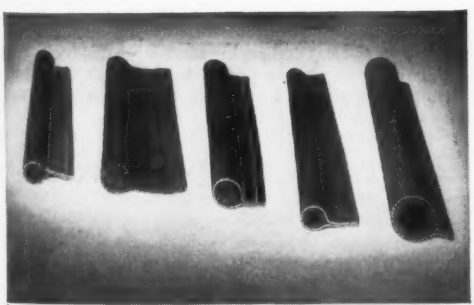

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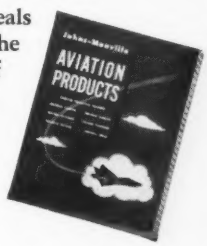

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tion of the sensitivity of reception of modulated signals and of continuous-wave signals.

Impulse Noise Limiters. Robert C. Moses. *Radio & Television News*, Vol. 45, No. 6 (*Radio-Electronic Engineering*, Vol. 16, No. 6), June, 1951, pp. 16, 18–21, illus. Qualitative and quantitative characteristics of three circuits.

POWER SUPPLIES

Ripple on Polyphase Rectifiers: The Effect of Applying Unbalanced Phase Voltages. J. E. Nixon. *Marconi Review*, Vol. 15, No. 101, 2nd Quarter, 1951, pp. 82–88, illus. 1 reference.

RADAR

Radar Countermeasures; Methods of Thwarting the "All-Seeing" Electronic Eye. Ted Powell. *Ordnance*, Vol. 35, No. 186, May-June, 1951, pp. 565–568, illus.

L-, S-, and X-Band Radar Echoes from Rifle Shells. Frank C. Macdonald. *U.S., Naval Research Laboratory, Washington, Report No. 3720*, August 14, 1950. 25 pp., illus. 1 reference.

TELEMETRY

Linear Discriminator for F-M Telemetering. Gordon S. Sloughter and Richard T. Ellis. *Electronics*, Vol. 24, No. 6, June, 1951, pp. 113–115, illus.

Design and operation of an unbalanced trigger circuit type of discriminator. Sixteen channels may be connected to the receiver simultaneously; subcarrier frequency range is 400 cycles per sec. to 70 kc.

TRANSMISSION LINES

Impedance Matching in Coaxial Lines with Sleeve and Undercut Impedance Transformers. C. B. Barker. *U.S., Naval Research Laboratory, Washington, Report No. 3752*, October 24, 1950. 17 pp., illus. 2 references. Derivation of mathematical formulas for determining dimensions of sleeve and undercut transformers on a coaxial line.

Coaxial-Stub Filter. James A. Craig. *Electronics*, Vol. 24, No. 6, June, 1951, pp. 132, 134, illus. Graphs give approximate stub lengths for any interfering frequency from 20 to 200 mc.

The Susceptance of a Thin Iris in Circular Waveguide with the TM_{01} Mode Incident. Kenneth L. Dunning and Rufus G. Fellers. *U.S., Naval Research Laboratory, Washington, Report No. 3726*, September 23, 1950. 29 pp., illus. 11 references.

By using Schwinger's integral equation method, formulas are developed for the susceptance of a thin iris. The susceptance of several irises was measured and compared with analytical results.

On the Systems of Linear Equations in the Theory of Guided Waves. W. Magnus and F. Oberhettinger. *Communications on Pure and Applied Mathematics*, Vol. 3, No. 4, December, 1950, pp. 393–410, illus. 13 references.

On the Theory of Electromagnetic Wave Diffraction by an Aperture in an Infinite Plane Conduction Screen. Harold Levine and Julian Schwinger. *Communications on Pure and Applied Mathematics*, Vol. 3, No. 4, December, 1950, pp. 355–391, illus. 9 references.

A Compact Broadband Microwave Quarter-Wave Plate. A. J. Simmons. *U.S., Naval Research Laboratory, Washington, Report No. 3748*, October 17, 1950. 10 pp., illus. 5 references.

Development of a design for a cascade of three capacitive pins to give any desired phase shift with no reflection. The technique is applied to the design of a short, 3-element quarter-wave plate.

WAVE PROPAGATION

Attenuation of Radio Signals Caused by Scattering. A. H. LaGrone, W. H. Henson, Jr., and A. W. Straiton. *Journal of Applied Physics*, Vol. 22, No. 5, May, 1951, pp. 672–674, illus. 3 references.

Abnormal E Region Ionization. N. C. Gerson. *Canadian Journal of Physics*, Vol. 29, No. 3, May, 1951, pp. 251–261, illus. 12 references.

Electromagnetic Scattering from Spheres with Sizes Comparable to the Wavelength. A. L. Aden. *Journal of Applied Physics*, Vol. 22, No. 5, May, 1951, pp. 601–605, illus. 16 references.

Asymptotic Solutions of a Differential Equation in the Theory of Microwave Propagations. Rudolph E. Langer. *Communications on Pure and Applied Mathematics*, Vol. 3, No. 4, December, 1950, pp. 427–438. 7 references.

Air-to-Air Tropospheric Radio Propagation. G. B. Fanning, F. P Miller, and G. J. Akerland. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 16, No. 5, May, 1951, pp. 19–24, illus. 1 reference.

Application of Microwave Channels. R. C. Cheek. *Electrical Engineering*, Vol. 70, No. 6, June, 1951, pp. 500–503, illus. 9 references.

Equipment

ELECTRIC (16)

Transient Fault Currents in Aircraft D-C Systems. D. G. Scorgie. *U.S., Naval Research Laboratory, Washington, Report No. 3744*, October 9, 1950. 17 pp., illus. 9 references.

Two simultaneous differential equations have been derived which satisfactorily describe the transient fault current in a shunt-wound aircraft d.c. generator in terms of easily obtainable parameters. Improved accuracy of the result is attributed to eliminating the assumption of constant field flux linkages during the transient and substituting the assumption of constant rates of change of field flux linkages with armature and field currents.

Effects of Terminal Voltage, Load Current and Minimum Rotor Speed on the Weight of D-C Aircraft Generators. D. H. Scott. *U.S., Naval Research Laboratory, Washington, Report No. 3649*, April 11, 1950. 74 pp., illus. 6 references.

Derivation of empirical equations for the relationships between total generator weight and power output for minimum rotor speed for the following conditions: terminal voltage, 30–120 volts; lead current, 100–400 amperes; minimum rotor speed, 3,000–8,000 r.p.m. A general description of d.c. aircraft generators and their operating conditions is included. Final generator weight curves were checked experimentally.

Flashing of DC Machines Caused by Short Circuits. A. T. McClinton and E. L. Brancato. *U.S., Naval Research Laboratory, Washington, Report No. 3735*, September 19, 1950. 13 pp., illus. 1 reference. Experimental study of the effects of initial speed, load, and commutating ability on the flashover characteristics of a 300-kw. d.c. generator.

Transient Analysis of Three-Phase Power Systems. II. Leonard Rabins and Eric T. B. Gross. *Franklin Institute, Journal*, Vol. 251, No. 5, May, 1951, pp. 521–537, illus. 9 references.

The relationships are set up between the three-phase problem and the equivalent Clarke components. All phases are symmetric, and only series impedances are considered. The method of Clarke components is extended to transient analysis by means of a network calculator.

HYDRAULIC (20)

Pressure Losses in the Flying Wing. Warde L. Parker *Applied Hydraulics*, Vol. 4, No. 5, May, 1951, pp. 48–52, illus.

Data on pressure losses in the entire hydraulic flight-control system which were obtained in tests of the Northrop Flying Wing. Test values were compared with pressure-drop calculated values. Curves show the variation of laminar, turbulent, and bend pressure-loss factors with temperature.

Convair P5Y Pneumatic System. Edmond C. Powers. *Aero Digest*, Vol. 62, No. 5, May, 1951, pp. 19, 74–64, illus.

Pneumatic Power. II—Design of Air Supply Systems. J. Alan Campbell. *Machine Design*, Vol. 23, No. 5, May, 1951, pp. 141–146, illus. Design factors of compressors to obtain desired pressure and capacity; types of compressors; oil and moisture condensation and removal; low-temperature uses.

Flight Operating Problems (31)

ICE PREVENTION & REMOVAL

Icing of "Low Drag" Wing Sections. I. S. Lal. *Aeronautical Society of India, Journal*, Vol. 3, No. 1, February, 1951, pp. 11–17, illus. 5 references.

Derivation of a theoretical method for estimating the performance of an arbitrary airfoil under icing conditions. Theodorsen's theory of potential flow about arbitrary airfoil sections is extended to a complete mapping of the velocity components in

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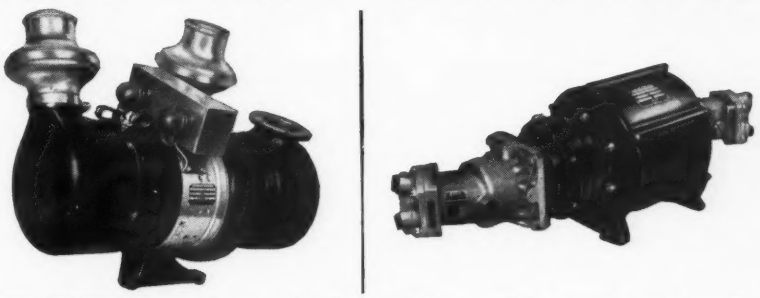
Working with the pioneers of in-flight refueling, Jack & Heintz has developed electric motors for hydraulic and fuel pumps and hydraulic boom actuators with special features required for this service.

The J&H DA15, a 9.5 hp, d-c motor with integral pump, boosts pressure to permit rapid fuel transfer from tanker planes. It operates in explosive atmospheres. Special arrestors on air inlet and outlet ducts confine flames from any possible explosion in the motor chamber, while relieving motor internal pressure harmlessly through the ducts.

Other features include thermal protection, self-cooling for continuous duty to 25,000 feet, and radio noise filter.

Positioning of the boom is accomplished with J&H D15 and D16 hydraulic actuators. The D15 extends and retracts the boom while the D16 raises and lowers it. Power for these actuators is supplied by a hydraulic pump driven by a J&H DA17 motor.



FUEL PUMP MOTOR shown on left, has integral pump, flame arrestors and thermal protection. Two J&H Hydraulic Actuators, like that on right, extend and hoist refueling boom. A J&H motor operates the hydraulic pump that powers these actuators.

Chief Engineer's Corner

The special motors for in-flight refueling are typical examples of special application aircraft motors J&H has developed. Our engineering department is organized to handle the unusual problems that arise in the development of special motors.

For instance, one of our customers required a motor with windings able to withstand boiling high octane gasoline. Available impregnation varnishes would not give satisfactory service. The materials section of the engineering department devised a new impregnation varnish that would withstand boiling gasoline for thousands of hours, with no perceptible change in insulating qualities. As a result, our DA19 motor is being used to power a new type of fuel booster pump, where it operates submerged in gasoline.

Another interesting development is the vest-pocket size DA22 motor, featuring a brake operated by the same magnetomotive force that turns the rotor. This eliminates many of the previous difficulties experienced with a-c brake motors. The motor is $2\frac{5}{16}$ in. o.d. and $3\frac{1}{2}$ in. long, weighs 2.1 lbs. and is rated at one-quarter hp at 10,500 rpm, on an intermittent duty basis.

If you need an aircraft motor, please submit all available environmental and application data. Our engineers will be glad to work with you to choose the best type and design to meet your needs. Write JACK & HEINTZ . . . Cleveland 1, Ohio.

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Exhaustive testing is a religion at Jack & Heintz. The ability of a device to meet normal conditions is just a beginning.

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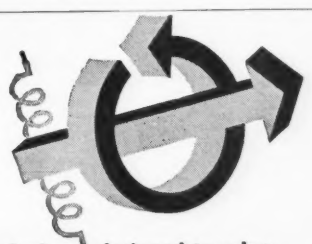
Because *Rotomotive* equipment must meet so many different conditions, we design and build much of the test equipment we use. Pictured is a laboratory workshop where test panels are being built and parts machined for other J&H test apparatus.

JACK & HEINTZ *Rotomotive* EQUIPMENT



means electrical, hydraulic or mechanical devices designed to solve unusual problems of developing power, controlling it, or using it.

the region in front of the airfoil to follow the path of the water droplets as they approach the airfoil.

Spray Nozzles for the Simulation of Cloud Conditions in Icing Tests of Jet Engines. N. Golitzine, C. R. Sharp, and L. G. Badham. *Canada, National Research Laboratories, Division of Mechanical Engineering, Engine Laboratory, Report No. ME-186,* August 28, 1950. 42 pp., illus. 6 references.

Tests on pneumatic and swirl-type spray nozzles for simulating natural cloud conditions in icing tests of jet engines. Figures are given for the water droplet sizes obtainable in sprays from nozzles of different sizes, at various conditions.

REFUELING IN FLIGHT

Flight Refueling Equipment Details (Aviation Design Progress). Randolph Hawthorne. *Aviation Age,* Vol. 15, No. 5, May, 1951, pp. 24, 25, cutaway drawings. Probe and drogue system produced by Flight Refueling, Inc.

Flight Safety & Rescue (15)

CAA Developments Provide Safer Aircraft. A. L. Morse. *SAE Journal,* Vol. 59, No. 5, May, 1951, pp. 29–33, illus. (Based on a paper: Some Developments for Safer Aircraft.)

Some Special Aspects of Air Transport Safety. C. M. Christenson. *Aeronautical Engineering Review,* Vol. 10, No. 7, July, 1951, pp. 23–26. Outline of the safety problems associated with the introduction of new equipment into air-line transportation.

Protection of Passengers and Air Crew from Air Blast Effects of Explosive Decompression. Barry G. King and J. J. Swearingen. *Flight Safety Foundation, Annual Safety Seminar, 3rd,* Denver, October 30, 1950. 4 pp., illus.

Tests were made at the Civil Aviation Medical Research Laboratories on dummies seated in regular aircraft seats next to plastic windows of the same dimensions as the Constellation, Convair, and DC-6 windows at pressure differentials of 2–7½ lbs. per sq.in. Rupturing the window simulated explosive decompression in an aircraft. A double-panel plastic window with apertures at the periphery of the inner pane is suggested to delay decompression up to 5 sec.

Review of Developments in Landing Speed Reduction and Hovering Aircraft. David H. Kaplan. *The Daniel & Florence Guggenheim Aviation Safety Center at Cornell University,* 2 East 64th Street, New York 21, N.Y., May, 1951. 8 pp., 74 references. $0.25.

Brief summary of progress; research on boundary-layer control, utilization of propeller slipstream; and flap and slot devices for reducing landing speed; aircraft design studies on ornithopters, Magnus effect aircraft, gyrodynes, and convertiplanes.

Safer Seating. W. E. Hick. *Aeronautics,* Vol. 24, No. 4, May, 1951, pp. 36, 37, illus. Merits of backward-facing seats for aircraft.

An Investigation of the Crash-Fire Problems in Transport Aircraft Fuel Tanks. R. L. Field, Melvin F. Miller, and George L. Pigman. *U.S., Civil Aeronautics Administration, Technical Development Report No. 134,* January, 1951. 21 pp., illus.

Analysis of results of C.A.A. test program and air-line accident experience to determine means of improving fuel tank design, construction, and location to provide personnel protection from fires arising from fuel-tank rupture in crashing.

Report on the Development of Protective Clothing for Handling Liquid Rocket Propellants. Eugene T. Hagan. *U.S., Air Force, Air Materiel Command, Engineering Division, Aero Medical Laboratory, Memorandum Report No. MCREXD-666-16K,* October 30, 1950. 11 pp., illus.

Use and Maintenance of Individual Land Survival Kits. N. K. Hanselman. *U.S., Air Force, Air Materiel Command, Engineering Division, Aero Medical Laboratory, Memorandum Report No. MCREXD-670-20K,* March 2, 1951. 17 pp., illus.

Flight Testing (13)

Flight Characteristics at High Mach Numbers. V. Outman and G. V. Graff. *Aircraft Engineering,* Vol. 23, No. 267, May, 1951, pp. 139–142, illus.

Development test flying of the McDonnell Banshee at high subsonic Mach Numbers. Test procedure included tuft tests, in which tufts of yarn were fastened to the wing and tail surfaces, and the in-flight conditions were photographed. Photographs show modifications of the tail surfaces to eliminate compressibility effects.

French Flight Testing Technique. Hussenot. *Shell Aviation News,* No. 154, April, 1951, pp. 20–23, illus. Instruments for analyzing and recording flight-test data.

Fuels & Lubricants (12)

Relation Between Gas Evolution and Physical Properties of Liquids. V. G. Szebehely. *Journal of Applied Physics,* Vol. 22, No. 5, May, 1951, pp. 627, 628, illus. 2 references.

Density, viscosity, and surface tension were measured for seven lubricating oils and three aircraft engine fuels, one of which was a jet-engine fuel; determination of the half-lives of evolution and solution.

Effect of Initial Mixture Temperature on Flame Speed of Methane-Air, Propane-Air, and Ethyle .e-Air ixtures. Gordon L. Dugger. *U.S., N.A.C.A., Technical Note No. 2374,* May, 1951. 30 pp., illus. 21 references. Initial mixture temperature range, 34°–344°C.

The Preparation, Physical Properties, and Heats of Combustion of Four Alkylsilanes. Stanley Tannenbaum and Maurice F. Murphy. *U.S., N.A.C.A., Research Memorandum No. E51A05,* March 8, 1951. 13 pp., illus. 13 references.

Study of the dependence of flame properties on the molecular structure for nonhydrocarbon fuels. Monoethylsilane, diethylsilane, trimethylsilane, and tetramethylsilane were prepared and tested to determine their boiling points, densities, refractive indexes, and freezing points.

Literature Review on the Prevention of Ice Crystal Formation in Fuels. J. M. Lloy. *Canada, National Research Laboratories, Division of Mechanical Engineering, Fuels and Lubricants Laboratory, Report No. MF-2891,* July 25, 1950. 55 pp., illus.

Survey of work on the prevention of the separation of alcohol-gasoline fuel into two layers in the presence of water. The literature reviewed covered 17 references on testing methods and 98 abstracts of articles. An author index is included.

The Viscosity-Surface Tension Relation for Petroleum Fuels. W. Sacks. *Canada, National Research Laboratories, Division of Mechanical Engineering, Fuels and Lubricants Laboratory, Report No. MF-2905,* December 5, 1950. 6 pp., illus. 6 references. Measurements of the surface tension and viscosity at 25°C. of various grades of aviation gasoline, aviation kerosene, diesel fuel, fuel oil, and AN-F-58a jet-engine fuel.

Some Industrial Experiences with Synthetic Lubricants. C. H. Sweatt and T. W. Langer. *Mechanical Engineering,* Vol. 73, No. 6, June, 1951, pp. 469–476, illus. 20 references. Properties of polyaklylene-glycol lubricants; practical and successful industrial experiences under various operating conditions.

Friction at High Sliding Velocities of Oxide Films on Steel Surfaces Boundary-Lubricated with Stearic-Acid Solutions. Robert L. Johnson, Marshall B. Peterson, and Max A. Swikert. *U.S., N.A.C.A., Technical Note No. 2366,* May, 1951. 35 pp., illus. 18 references.

Experiments were conducted to establish the capabilities of a fatty acid (stearic) as an additive for lubrication of steel surfaces at high sliding velocities (75 to 7,000 ft. per min.) with severe loading and to determine the efficacy of prepared oxide films in this type of lubrication.

Report on the Development of Protective Clothing for Handling Liquid Rocket Propellants. Eugene T. Hagan. *U.S., Air Force, Air Materiel Command, Engineering Division, Aero Medical Laboratory, Memorandum Report No. MCREXD-666-16K,* October 30, 1950. 11 pp., illus.

Gliders (35)

The Role of the Sailplane in Aerodynamic Research. August Raspet. *Soaring,* Vol. 15, No. 3, May-June, 1951, pp. 10, 11. 3 references.

Speed in Gliding; Some Suggested Methods for Use in Planning Cross-Country Flights. J. C. Neilan. *Flight,* Vol. 59, No. 2206, May 4, 1951, pp. 524, 525, illus.

The Future of the High Performance Sailplane. J. C. Reussner. *Aeronautics,* Vol. 24, No. 4, May, 1951, pp. 28–31, illus.

Assessment of sailplane performance factors and effect of aspect ratio on performance to show that conventionally designed sailplanes have reached their peak in performance and that de-

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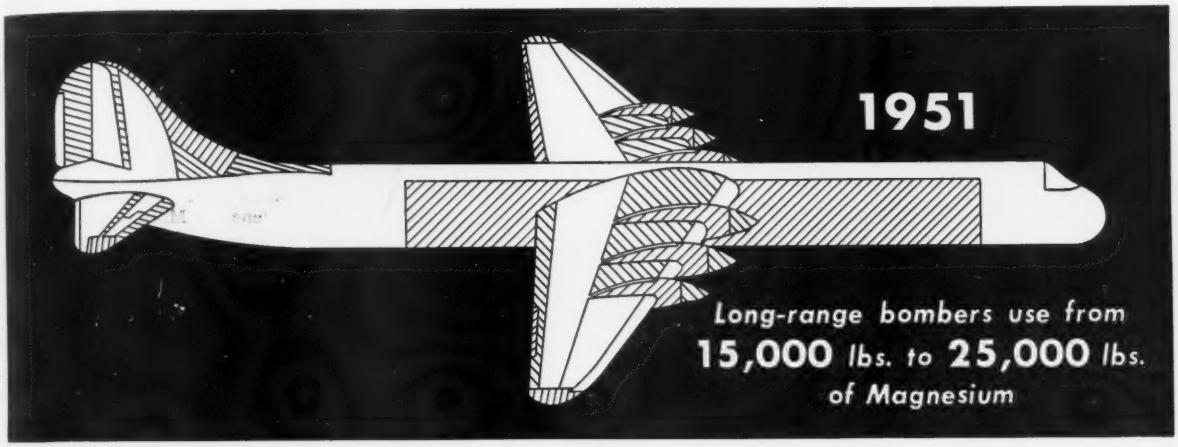

1940—Long-range bombers used 1,000 lbs. of Magnesium in Engine castings and wheels

Magnesium used in 1951 Bombers:

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- Wing skins, including de-icer system
- Control surface skins
- Bomb bay doors
- Propeller spinners
- Waffle grid stiffeners
- Formers and air ducts
- Many airframe castings
- Nacelle skins
- Engine castings
- Wheels, brakes, gun turrets
- Radar, radio and fire control equipment

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Although it served the purpose at the time, there's nothing quite so obsolete as "yesterday's" airplane. Today's planes have the kind of "get-up-and-go" that really counts. The modern bomber carries heavier loads for greater distances at higher altitudes than ever before.

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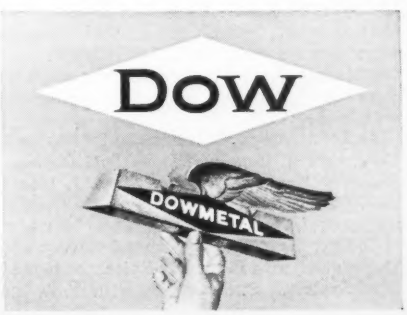

sign refinements, such as laminar-flow airfoils, reduced drag, and tailless craft, are needed for increased performance.

Guided Missiles (1)

On the Accuracy of the Long-Range Ballistic Rocket. W. E. Frye. *Journal of Applied Physics*, Vol. 22, No. 5, May, 1951, pp. 585–589. 5 references. Error analysis of a V-2-type ballistic rocket throughout its flight period.

Evolution of the Guided Missile. I. Kenneth W. Gatland. *Flight*, Vol. 59, No. 2206, May 4, 1951, pp. 534–537, illus. Review of guided-missile developments in Germany and the U.S.; generalized outline of guidance techniques; status of British research.

Instruments (9)

French Flight Testing Technique. Hussenot. *Shell Aviation News*, No. 154, April, 1951, pp. 20–23, illus.

Features of the A.11 and A.20 continuous analyzers that record flight-test data on photographic strips. The recorders work off a time base and tracers that are mechanical, pneumatic, or electric instruments controlling a small mirror. The mirror reflects a beam of light through a slot onto the moving strip of photographic paper. A cinetheodolite, consisting of a 40-frame per sec. motion-picture camera and an A.20 analyzer, is under development.

The Rate Table. Henry J. Stinger. *Progress Through Research*, Vol. 5, No. 3, Spring, 1951, pp. 8–13, illus.

Design of a rotating circular table driven by precise gearing and having a delicate control system for precision testing of rate gyroscopes. The Rate Table, developed by the General Mills Aeronautical Research Laboratories, is driven by a servomechanism of the eddy current, clutch-brake type. Its speed is accurate to 0.002 per cent; vibration does not exceed 5.0×10^{-5} of an inch.

Lear Instrument Assembly. *Aero Digest*, Vol. 62, No. 5, May, 1951, pp. 20–25, illus. Pictures show operations and stress dust-free conditions in the gyro assembly department of Lear, Inc.

A Tested Solution of the Problem of Helicopter Stability and Automatic Control. Donald N. Meyers, Edward G. Vanderlip, and P. Halpert. *Aeronautical Engineering Review*, Vol. 10, No. 7, July, 1951, pp. 27–32, illus. Principles of the Sperry A-12 gyropilot which make it adaptable for automatic control of helicopters; installation in the Piasecki XHJP-1; performance evaluation.

A Design Procedure for a Simple Automatic Control for Model Aircraft. B. E. Swire. *Australia, Department of Supply, Aeronautical Research Laboratories, Instruments Note No. 51*, November, 1950. 42 pp., illus. 2 references.

Design of a control instrument for improving the azimuth stability of powered model aircraft in flight. The instrument uses a single-rate gyroscope that senses rate of yaw. A simplified and approximate form of the transfer function is the basis for the design.

Some Design Criteria for Automatic Controls. P. T. Nims. *Electrical Engineering*, Vol. 70, No. 5, May, 1951, p. 395.

Controller Settings for Optimum Control. W. A. Wolfe. *American Society of Mechanical Engineers, Transactions*, Vol. 73, No. 4, May, 1951, pp. 413–418, illus. 3 references.

Study of the problem of optimum settings and development of criteria for obtaining the settings. The Laplace transform is applied to an idealized plant, and the resulting equations are solved for the optimum conditions.

Tests on the Effect of Incidence on Some Pressure Heads at High Subsonic Speeds. E. W. E. Rogers and C. J. Berry. *Gt. Brit., Aeronautical Research Council, Current Papers No. 41*, 1951 (July 21, 1950). 13 pp., illus. 6 references. British Information Services, New York. $0.50. A venturi-pitot tube, the Mk.VIIIA pitot-static head, and small pitot and static tubes were tested at $M = 0.7$–0.9 to determine the loss in total head with incidence.

An Electromagnetic Flowmeter for Rocket Research. Leonard Jaffe, Bert A. Coss, and Donald R. Daykin. *U.S., N.A.C.A., Research Memorandum No. E50L12*, March 6, 1951. 15 pp., illus. 1 reference. Design of an electromagnetic flowmeter for measuring instantaneous flow rates of liquid rocket propellants.

Cockpit Lighting: A General Survey of the Principles and Techniques, with Particular Reference to the Development of the Dual System. E. S. Calvert. *Gt. Brit., Aeronautical Research Council, Current Papers No. 36*, 1951 (1946). 40 pp., illus. 16 references. British Information Services, New York. $1.25.

Properties of the dark-adapted eye and rules derived from them; geometric relationships necessary in a cockpit to prevent reflections and to permit cockpit illumination by a system of direct lighting (such as the Dual System); methods of cockpit lighting.

Blind Flying Panels and Instruments. O. W. Neumark. *Institute of Navigation, Journal*, Vol. 4, No. 2, April, 1951, pp. 201–205, illus. Suggested cockpit layouts for gyro instruments in high-speed aircraft.

A Three-Channel Piezo-Electric Pressure Recorder. P. J. Fletcher. *Gt. Brit., Aeronautical Research Council, Current Papers No. 35* (*Memorandum No. M.64*), 1951 (November, 1949). 12 pp., illus. 2 references. British Information Services, New York. $0.40.

Design and operation of a recorder for cascade wake readings. Pressures are led to the inlet ports of a motor-driven rotary valve that applies them in sequence to the diaphragm of a quartz-crystal pickup. From this, the signals are amplified and indicated on a cathode-ray oscilloscope. Traces are photographed on 35-mm. motion-picture film.

An Electromechanical Transducer. J. F. Engelberger and H. W. Kretsch. *Electrical Engineering*, Vol. 70, No. 5, May, 1951, pp. 437–440, illus. 12 references. Electronic circuit design, applications, accuracy, and frequency response of the Microsen Balance. The balance is a compact torque balance device.

Investigation of Stress-Strain Properties of Metal Wires by Electrical Resistance Changes. Irwin Vigness. *U.S., Naval Research Laboratory, Washington, Report No. 3745*, October 3, 1950. 10 pp., illus. 5 references. The tensile stress-strain characteristics are obtained from an oscillographic record of the resistance of the wire.

Multi-Channel Measurement of Physical Effects by Confluent Pulse Technique, with Particular Reference to the Analysis of Strain. J. G. Yates, D. H. Lucas, and D. L. Johnston. (*I.E.E., Measurements Section, Paper No. 1032.*) *Institution of Electrical Engineers, Proceedings, Part II, Power Engineering*, Vol. 98, No. 62, April, 1951, pp. 109–121, Discussion, pp. 121–124, illus. 9 references. Investigation of measurement in impedance bridges by pulse excitation; design of a 10-channel strain-gage indicator; recording apparatus.

Dynamomètre 191. G. Faure. *La Recherche Aéronautique*, No. 20, March-April, 1951, pp. 43–45, illus. In French. A resistance-wire strain-gage dynamometer for measuring aircraft control-system forces up to ±150 kg. with an accuracy of 2 per cent.

The Improved Ramberg Vacuum Tube Accelerometer. *Aero Digest*, Vol. 62, No. 5, May, 1951, pp. 44, 46, 94, illus.

Improvements, including stops to limit plate motion, support rods to increase the sensitivity, and a second getter, provide for a greater range of acceleration measurement, higher output voltages, and damping of natural frequency responses.

Modification of Portable Strain Indicator for Use with a Closed External Bridge Circuit. C. E. Bowman and W. J. Craig. *Instruments*, Vol. 24, No. 5, May, 1951, p. 533, illus. 3 references. Modification of the Baldwin "Type K" portable strain indicator by the addition of a closed circuit of four active gages.

The Direct-Reading D-C. Strain-Gage Bridge. II. Robert W. Troke. *Instruments*, Vol. 24, No. 5, May, 1951, pp. 535, 536, 538, 540, 542, 544, illus. Analysis of strain-gage performance; design equations; measurement of forces with a strain gage; sensitivity and data reliability.

Machine Elements (14)

Machine Design Data Sheet: Design Factors for Stress Concentration. III—Fillets in Bending. R. E. Peterson. *Machine Design*, Vol. 23, No. 5, May, 1951, pp. 159–163, illus.

Graphs give stress-concentration factors for flat bars and shafts with shoulder fillets in bending, combined stress-concentration and shear-energy factor for a shaft with shoulder fillet in bending, and the stress-concentration factor for filleted bars with short shoulder lengths in bending.

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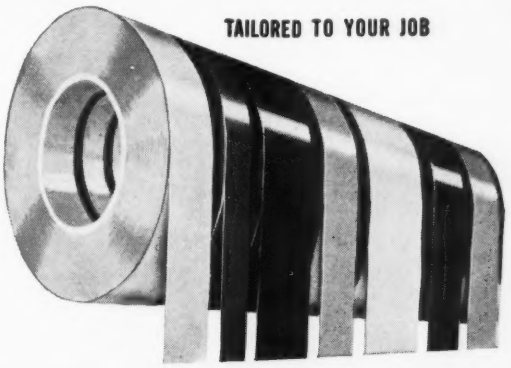

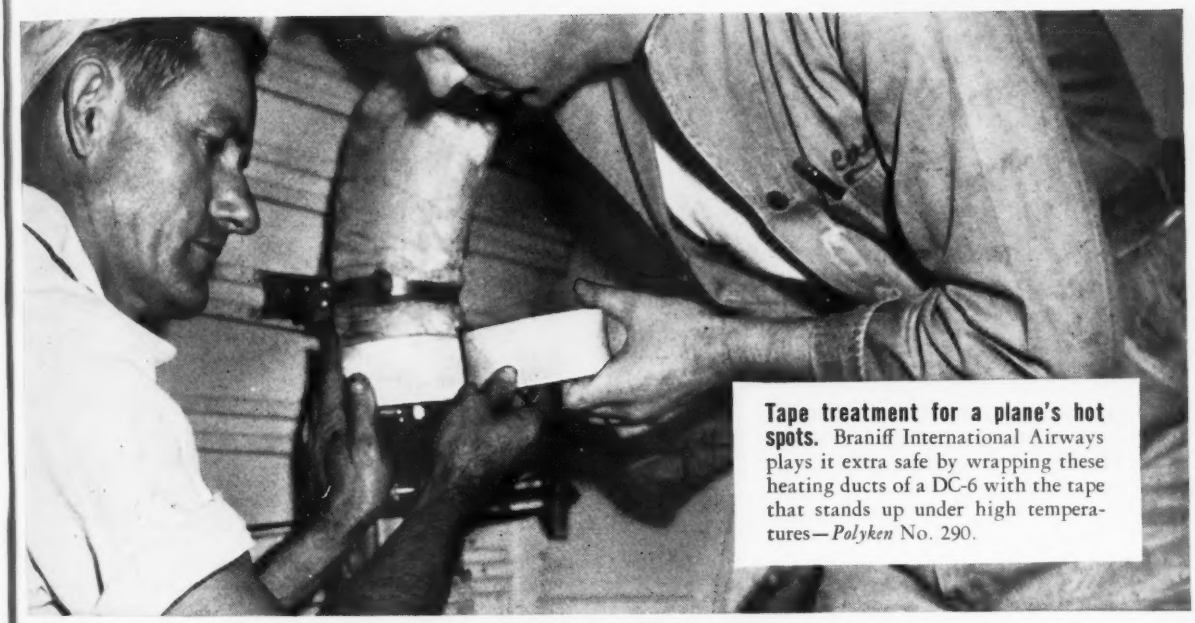

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SHAFTS & ROTATING DISCS

General Plastic Behavior and Approximate Solutions of Rotating Disk in Strain-Hardening Range. M. H. Lee Wu. *U.S., N.A.C.A., Technical Note No. 2367*, May, 1951. 56 pp., illus., folding chart. 14 references.

Derivation of a partly linearized solution and two methods of numerical solution for the plastic deformation of a rotating disc. Calculated values agree well with experiments.

Maintenance (25)

Corrosion Problems Related to Air Transport Aircraft. O. E. Kirchner and F. M. Morris. *Corrosion*, Vol. 7, No. 5, May, 1951, pp. 161–177, illus.

Corrosion problems related to air-transport aircraft, their causes and treatment, and prevention of such corrosion by proper design, maintenance or surface treatments, and cleaning operations.

Tanks Stripped Faster and Cleaner. *Aviation Week*. Vol. 54, No. 18, April 30, 1951, pp. 39, 41, 43, illus.

Turco stripper 2822 thin is sprayed under pressure into integral fuel tanks by a Pyrate automatic tank washer. A dummy access door, containing the inlet and outlet lines for the stripper, is fastened on the fuel tank in place of the usual door.

Airlines Gain in Extending Overhaul Times. *American Aviation*, Vol. 14, No. 45, May 28, 1951, pp. 26, 27, tables.

Local Service Aircraft and Engines Maintenance Requirements. Charles L. Baker. *S.A.E., National Aeronautic Meeting, April 16–19, 1951, Preprint No. 613*. 6 pp.

Materials (8)

The Hardness and Strength of Metals. D. Tabor. *Institute of Metals, Journal*, Vol. 79, Part 1, 1951. 18 pp., illus. 10 references. Reprint.

Analysis of hardness tests with a spherical indenter (the Brinnell test) and tests with pyramidal indenters (Vickers hardness measurements); derivation of the true stress-strain curve.

CERAMICS & CERAMALS

Some Properties of Beryllium Oxide and Beryllium Oxide-Columbium Ceramals. C. F. Robards and J. J. Gangler. *U.S., N.A.C.A., Research Memorandum No. E50G21*, March 2, 1951. 18 pp., illus. 3 references.

Investigation of the short-time tensile strength of BeO at 1,800°F.; thermal shock resistance at 1,800° and 2,000°F.; and the effect of adding 2, 5, 8, 10, 12, and 15 per cent Cb metal on the thermal shock properties of BeO.

Selected Bibliography of Engineering Subjects. IV—Ceramic Engineering. *Engineers' Council for Professional Development*, 1951. 8 pp. List of 145 references, each with a descriptive annotation, classified under 15 headings.

Ceramics: Exhaust Protection. *Aviation Week*, Vol. 54, No. 21, May 21, 1951, p. 30, illus. Status of Ryan Aeronautical Company's research program on thin ceramic coatings for exhaust-system components of reciprocating engines.

METALS & ALLOYS

Sampling of Ferrous and Non-Ferrous Alloys—A Bibliography. Albert C. Holler. *American Society for Testing Materials*, No. 174, May, 1951, pp. 66, 67. 52 references.

A Hundred Years of Metallurgy, 1851–1951. I. Leslie Aitchison. *Sheet Metal Industries*, Vol. 28, No. 289, May, 1951, pp. 405–424, illus.

Cooperative Investigation of Relationship Between Static and Fatigue Properties of Heat-Resistant Alloys at Elevated Temperatures. N.A.C.A. Subcommittee on Heat-Resisting Materials. *U.S., N.A.C.A., Research Memorandum No. 51A04*, March 7, 1951. 51 pp., illus. Data covering combinations of steady tensile stress with superimposed dynamic stress, and completely reversed stress fatigue tests.

Tensile-Fracturing Characteristics of Several High-Temperature Alloys As Influenced by Orientation in Respect to Forging Direction. W. F. Brown, Jr., H. Schwartzbart, and M. H. Jones. *U.S., N.A.C.A., Research Memorandum No. E50L28*, February 12, 1951. 32 pp., illus. 13 references. Tests on forged and heat-treated billets of alloys 16-25-6, S-816, and Inconel X.

Ten Years Progress in Gas-Turbine Metals. *The Aeroplane*, Vol. 80, No. 2077, May 11, 1951, pp. 585, 586, illus.

Review of development of the ferritic and austenitic steels and nonferrous alloys (based on 80 per cent Ni, 20 per cent Cr) and their application to gas-turbine construction; characteristics of the metals.

A Study of Austenite Transformation by X-Ray Diffraction. L. S. Birks. *U.S., Naval Research Laboratory, Washington, Report No. 3749*, October 12, 1950. 6 pp., illus. 4 references. Specimen preparation, test procedure and apparatus, results.

A Note on the Tensile Strength and Elongation of Wide Plates of Aluminium Alloy with and Without Holes. H. E. Smith and H. L. Cox. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2429*, 1951 (August, 1944). 8 pp., illus. British Information Services, New York. $0.50.

Test procedure and results to determine the effects of small holes on the tensile strength of aluminum alloy sheet and to assess holes reinforced with cover rings and with pressed flanges.

Étude des Alliages Magnésium-Aluminium: Affinage et Protection contre l'Inflammation. Albert Keil and Pierre Bertin. *La Recherche Aéronautique*, No. 20, March-April, 1951, pp. 3-9, illus. 5 references. In French.

Foundry methods as they affect grain refinement of Mg-Al alloys; characteristics of Mg-Al-Zn-Be alloys; grain size and Zn-Be constituents; advantageous mechanical properties of an Mg-4 Al-1 Zn-0.01 Be alloy; protection against burning up to 780°C.

The Plastic Deformation of Pure Single Crystals of Lead and Copper. Peter W. Neurath and James S. Koehler. *Journal of Applied Physics*, Vol. 22, No. 5, May, 1951, pp. 621–626, illus. 3 references.

Mechanical behavior of 99.999 per cent pure lead and copper at small strains over a temperature range of 23°C. to −190°C. for Cu and 25° to 110°C. for Pb. The crystals were grown by the Bridgeman method. A tensile creep apparatus was designed and constructed for these tests; it operated in the strain range of 2×10^{-6} to 4×10^{-2}.

NONMETALLIC MATERIALS

Some Mechanical Properties of Graphite at Elevated Temperatures. C. Malmstrom, R. Keen, and L. Green, Jr. *Journal of Applied Physics*, Vol. 22, No. 5, May, 1951, pp. 593–600, illus. 13 references. Experimental procedures and results of tension and creep tests on various grades of graphite at temperatures up to 3,000°C.

The Practical Determination of Strength of Doped Fabric. H. Kendall King, Cecil B. Phillips, and Alan L. Morse. *U.S., Civil Aeronautics Administration, Technical Development Report No. 129*, November, 1950. 17 pp., illus. 4 references.

The Elevated Temperature Creep and Fatigue Properties of a Polyester Glass Fabric Laminate. William N. Findley and Will J. Worley. *Society of Plastics Engineers, Journal*, Vol. 7, No. 4, April, 1951, pp. 9–17, illus. 11 references.

Test procedures, specimen preparation, test apparatus, test data, and analysis of results of tension and compression tests at 77°F., time-to-fracture creep tests at 77° and 400°F., fatigue tests at 77°F. in still air and in an air blast, and fatigue tests at 77° and 300°F. on glass-fabric laminates molded at 13 lbs. per sq.in. pressure with Laminac 4126 polyester resin.

Plastics for Aircraft Parts. I. Gilbert C. Close. *Aviation Age*, Vol. 15, No. 5, May, 1951, pp. 32, 33, illus.

Étude d'une Méthode de Mesure du Frottement Intérieur de Revêtements Plastiques Travaillant en Flexion. P. Liénard. *La Recherche Aéronautique*, No. 20, March–April, 1951, pp. 11–22, illus. 6 references. In French. A method of measuring the internal friction of various plastic shells in bending; description of photoelectric measuring equipment; discussion of test results.

PROTECTIVE COATINGS

Corrosion Problems Related to Air Transport Aircraft. O. E. Kirchner and F. M. Morris. *Corrosion*, Vol. 7, No. 5, May, 1951, pp. 161–177, illus.

Corrosion problems related to air-transport aircraft, their causes and treatment, and prevention of such corrosion by proper design, maintenance of surface treatments, and cleaning operations.

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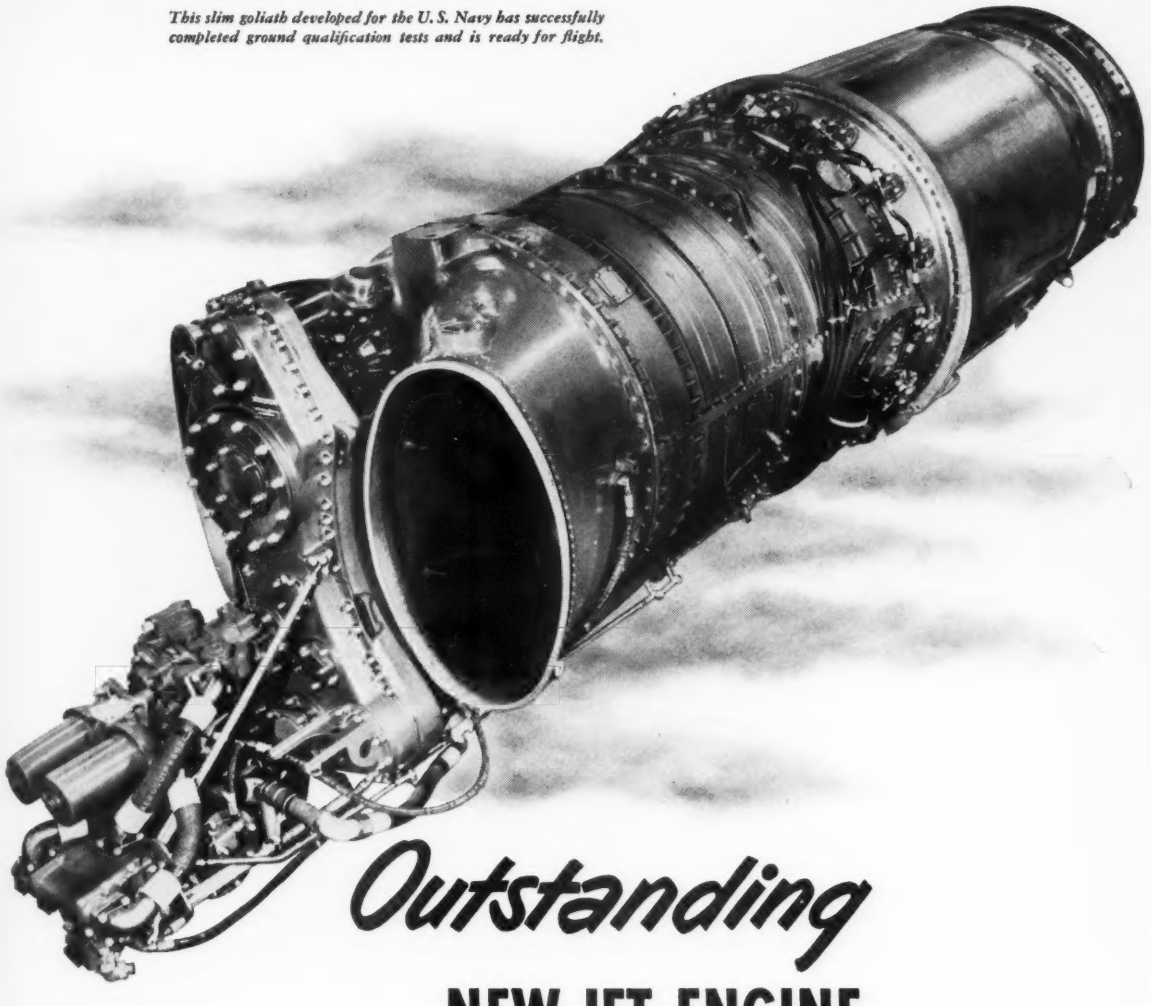

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HAE, Revolutionary New Coating for Magnesium. *Magazine of Magnesium*, May, 1951, pp. 1–3, illus. Characteristics of HAE coating for Mg and Mg alloys; applications of HAE-coated Mg.

Meteorology (30)

A Cloudform-Stability Scale for Tropical Oceanic Areas. Reid A. Bryson. *American Meteorological Society, Bulletin*, Vol. 32, No. 4, April, 1951, pp. 146–150, illus. 3 references.

On the Systematic Influence in Series of Annual Rainfall Totals. L. W. Pollak. *Ireland, Meteorological Service, Geophysical Publications*, Vol. 3, No. 5, 1951. 35 pp., illus. 63 references. Government Publications Sale Office, Dublin. 18*s*.

Studies on the Distribution and Forecasting of Hail in Western United States. H. T. Harrison and W. B. Beckwith. *American Meteorological Society, Bulletin*, Vol. 32, No. 4, April, 1951, pp. 119–131, illus. 13 references.

Photolytic Inactivation of Ice-Forming Silver Iodide Nuclei. Edward C. Y. Inn. *American Meteorological Society, Bulletin*, Vol. 32, No. 4, April, 1951, pp. 132–135, 6 references. Experimental investigation of the spectral sensitivity and photolytic action of silver iodide.

The Computation of Atmospheric Pressure at the 8 KM. Level of Constant Air Density. M. Doporto. (*Ireland, Meteorological Service, Technical Note No. 1*, January 11, 1943.) *Ireland, Meteorological Service, Geophysical Publications*, Vol. 3, No. 4, 1951. 17 pp., illus. 6 references. Government Publications Sale Office, Dublin. 7*s*. 6*d*.

The Brightness and Polarization of the Daylight Sky at Altitudes of 18,000 to 38,000 Feet Above Sea Level. D. M. Packer and C. Lock. *U.S., Naval Research Laboratory, Washington, Report No. 3713*, July 31, 1950. 59 pp., illus. 7 references.

Flight Instrument for Measurement of Liquid-Water Content in Clouds at Temperatures Above and Below Freezing. Porter J. Perkins. *U.S., N.A.C.A., Research Memorandum No. E50J12a*, March 5, 1951. 13 pp., illus. 5 references.

An Air-Launched Automatic Weather Station. *U.S., National Bureau of Standards, Technical News Bulletin*, Vol. 35, No. 5, May, 1951, pp. 61–63, illus.

Radar Observations of a Frontal Storm. Pauline M. Austin. *American Meteorological Society, Bulletin*, Vol. 32, No. 4, April, 1951, pp. 136–145, illus. 6 references.

Essay on Frontogenesis and Frontolysis. H. H. Lamb. *Meteorological Magazine*, Vol. 80, No. 944, February, 1951, pp. 35–46, illus. 7 references.

Upper Atmosphere Research Report. XII—Direct Measurements of Solar Extreme Ultraviolet and X-Rays from Rockets by Means of a $CaSO_4$:Mn Phosphor. K. Watanaba, J. D. Purcell, and R. Tousey. *U.S., Naval Research Laboratory, Washington, Report No. 3733*, September 18, 1950. 48 pp., illus. 54 references.

Military Aviation (24)

The Strategic Importance of Military Air Transport. Carl H. Amme, Jr. *U.S. Naval Institute, Proceedings*, Vol. 77, No. 5, May, 1951, pp. 457–465, illus.

Naval Aviation Today; Organization, Structure, and Composition. C. B. Bailey-Watson. *Flight*, Vol. 59, No. 2204, April 20, 1951, pp. 451–456, 463–466, illus.

H.M. Aircraft Carriers; A Review of Britain's Sea-Going Air Bases. C. B. Bailey-Watson. *Flight*, Vol. 59, No. 2204, April 20, 1951, pp. 457–462, illus. Cutaway drawing of H.M.S. "Indomitable."

Navigation (29)

Optimum Flight Paths. D. O. Fraser. *Institute of Navigation, Journal*, Vol. 4, No. 2, April, 1951, pp. 178–200, illus. 13 references.

Theoretical and empirical methods of calculating the optimum path for a long flight, including the effects of varying wind velocities. Criteria for selecting the optimum path are given, and methods of selection used by air lines are compared.

Light Aircraft Navigation. Michael Townsend. *Institute of Navigation, Journal*, Vol. 4, No. 2, April, 1951, pp. 167–177, illus.

Navigational problems encountered in a round-the-world flight in the northern hemisphere in 1948. The aircraft used were a

Proctor IV and a Vultee Variant. Navigation equipment consisted of a P8 compass, astrocompass, Mark IXa bubble sextant, Dreisonstok tables and 1:1M topological maps, in addition to single-channel V.H.F. radio equipment. Navigation procedures and use of equipment are explained.

The "Universal" Sea and Air Navigation Tables and the *a* and *b* Almanac. F. Radler de Aquino. *Institute of Navigation, Journal*, Vol. 4, No. 2, April, 1951, pp. 109–116, illus. 3 references.

The Common System As Viewed by the Airline Operator. Leslie O. Barnes. *Talk delivered before the Airport Operators Council Fourth Annual Conference, Memphis, Tenn.*, April 19, 1951. 12 pp.

How the Common System of Air Navigation Will Work. Richard E. Stockwell. *Aviation Age*, Vol. 15, No. 5, May, 1951, pp. 27–31, illus.

Operational details and components of the transitional system, developed by the Operational Policy Group of the Air Coordinating Committee's Air Traffic Control and Navigation Panel, which will be put into practice at Washington National Airport. Tables list suppliers of electronic control aids.

Aircraft Navigation Instruments. W. L. Webb. *Electrical Engineering*, Vol. 70, No. 5, May, 1951, pp. 384–388, illus.

Brief descriptions of the design and operation of the magnetic heading indicator, automatic-direction-finder indicator, radio magnetic indicator, omnirange bearing selector, cross-pointer indicator ID-48, omnibearing converter indicator, distance indicator, and omnimagnetic indicator.

Parachutes

Wind-Tunnel Experiments on the Squidding of Parachutes. L. F. G. Simmons, R. W. F. Gould, and C. F. Cowdrey. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2523*, 1951 (November 8, 1943). 19 pp., illus. 4 references. British Information Services, New York. $1.00.

Power Plants

Power Versus Weight in Aviation. Maurice Roy. (The 4th Louis Bleriot Lecture, February 23, 1951.) *Royal Aeronautical Society, Journal*, Vol. 55, No. 485, May, 1951, pp. 265–281, illus. 2 references.

Evolution of high-speed aircraft: aerodynamic advances brought about by air-frame weight reduction, increases in power-plant efficiency, new power-plant types, trends toward high speeds.

The Efficiency of Heat Engines. I. W. Traupel. (*Teknisk Tidskrift*, Vol. 80, No. 46, December 16, 1950, pp. 1157–1164.) *The Engineers' Digest*, Vol. 12, No. 4, April, 1951, pp. 117–119, illus. Development of a theory, valid for all types of heat engines, for calculating the thermal efficiency and for assessing losses of heat engines having one or more working media.

The Atom: Power for Flight. I. David A. Anderton. *Aviation Week*, Vol. 54, No. 21, May 21, 1951, pp. 21, 22, 24, 25, 27, 29, illus. Review of theory of atomic fission and of the energies released in the process.

Die Verwendung von Kernenergie zum Raketenantrieb. N. Scholz. *Weltraumfahrt*, No. 2, April, 1951, pp. 40–44, illus. 1 reference. In German. The application of nuclear energy to rocket propulsion; propellant exhaust velocities; temperatures.

JET & TURBINE (5)

Designs of a Decade; A Review of Turbojet and Turboprop Power Units; Some of the Problems Involved. C. B. Bailey-Watson. *Flight*, Vol. 59, No. 2207, May 11, 1951, pp. 559–570, illus., cutaway drawings. British engine developments; progress in U.S., France, Sweden, and Russia. Tables give available data on British and foreign current jet-engine types.

The Secret Years; An Account of Jet Developments Prior to the Official Disclosure in January, 1944. *Flight*, Vol. 59, No. 2207, May 11, 1951, pp. 550–552, illus.

Seventh Partial Report on the Pulse-Jet Engine; Measurement of the Air-Fuel Ratio. D. W. Baker. *U.S., Naval Research Laboratory, Washington, Report No. 3741*, October 6, 1950. 12 pp., illus. 4 references. Experimental study of the exhaust of a pulse-jet engine to determine if the air-fuel ratio can be obtained by a chemical analysis of the combustion products.

Static Pressures and Air Flows in the Flame Tube of a Derwent V Combustor. R. E. Pavia. *Australia, Department of Supply, Aeronautical Research Laboratories, Engines Note No. 154*, January, 1951. 24 pp., illus. 4 references.

Tests at combustor inlet velocity of 365 ft. per sec. (constant airflow of 9,300 lb. per hr.) and fuel-air ratios of 0–0.020 to determine the proportioning of airflows through groups of metering holes in the flame tube. Another series of tests was made at lower airflows (down to 2,000 lb. per hr.) to find the effect of total air quantity on the flow proportioning.

Simplified Design Comparison of Axial Compressors. Frank L. Wattendorf. *Journal of the Aeronautical Sciences*, Vol. 18, No. 7, July, 1951, pp. 447–459, illus. 13 references.

A comparative analysis of the relationship between stage temperature rise and the mass-flow ratio is developed for compressor types designed according to principles such as free vortex flow, rigid-body prerotation, and arbitrary and nonconstant distribution of rotor work. The influence of hub ratio, axial Mach Number, and blade temperature distribution are considered.

The Effect of Changes in Altitude on the Controlled Behavior of a Gas-Turbine Engine. Seymour C. Himmel and Richard P. Krebs. *Journal of the Aeronautical Sciences*, Vol. 18, No. 7, July, 1951, pp. 433–441, illus.

Presentation of a theory of the change in engine response with altitude, and experimental data confirming the theory. The variation in dynamic performance of the engine with altitude is determined analytically from the equation describing the dynamic behavior of a turboprop engine; tests were run in the N.A.C.A. Altitude Tunnel at altitudes of 10,000, 20,000, and 30,000 ft. to determine directly the dynamic performance. The analysis leads to additional requirements for the engine control system.

Has Allison Won the Jet Engine Race? Paul H. Wilkinson. *Aviation Age*, Vol. 15, No. 5, May, 1951, pp. 34, 35, illus. Design details and specifications of the Allison J35-A-23 10,000-lb. thrust turbojet.

Turbojet Engine Design. M. V. Hurley. *Aero Digest*, Vol. 62, No. 5, May, 1951, pp. 56–58, 82, 84–88, illus. Primary design considerations.

The Development of the Aircraft Gas Turbine in Great Britain and Its Influence on Petroleum Requirements. I. K. C. Hunt. *Esso Air World*, Vol. 3, No. 5, March-April, 1951, pp. 119–125, illus. (Paper presented before the S.A.E., New York, January 4, 1951.)

A Cheap Power Unit for Light Aircraft. I. Peter Kahn. *The Aeroplane*, Vol. 80, No. 2074, April 20, 1951, pp. 480, 481, illus. Theoretical possibilities of a power-plant unit that utilizes ram-jets attached to the tips of the propeller; practical considerations.

Theoretical Comparison of Several Methods of Thrust Augmentation for Turbojet Engines. Eldon W. Hall and E. Clinton Wilcox. *U.S., N.A.C.A., Report No. 992*, 1950. 11 pp., illus. 4 references. Superintendent of Documents, Washington. $0.20.

Theoretical investigation of tailpipe burning, water injection at the compressor inlet, combination tailpipe burning plus water injection, bleed-off, and rocket-assist methods of thrust augmentation.

Flight Performance of a Jet Power Plant. III—Operating Characteristics of a Jet Power Plant As a Function of Altitude. F. Weinig. (*Stuttgart, Technische Hochschule, Forschungsinstitut für Kraftfahrwesen und Fahrzeugmotoren, FB 1743/3*, November 1, 1943.) *U.S., N.A.C.A., Technical Memorandum No. 1258*, May, 1951. 40 pp., illus.

The performance of a jet power plant consisting of a compressor and a turbine is determined by the characteristic curves of these component parts and is controllable by the characteristics of the compressor and turbine in relation to each other. The normal output, overload, and throttled load are obtained on the basis of assumed straight-line characteristics.

24,000-H.P. Dynamometer Tests Jet Engines. M. Gay, W. F. King, and D. Dalasta. *Allis-Chalmers Electrical Review*, Vol. 16, No. 1, 1st Quarter, 1951, pp. 23–30, illus.

Design and operation of the Allis-Chalmers dynamometer, designed for P.&W.A., which is capable of transmitting torque to the equipment under test at speeds from 1,210 to 15,072 r.p.m. in either direction. A direct measurement of the torque is obtained because the motor and gear are mounted on a single base supported by four hydrostatic bearings.

RECIPROCATING (6)

The Design of Bearings for Piston Engines; Application of the Theory of Effective Loads. I—The Basis of the Theory. II—Calculating Bearing Loads in Piston Engines. A. K. Diachkov. (*Akademiia Nauk S.S.S.R., Leningrad, Izvestiia*, No. 11, November, 1950, pp. 1615–1644.) *The Engineers' Digest*, Vol. 12, No. 4, April, 1951, pp. 119–122, illus. 1 reference.

The Design and Development of the Twin-Centaurus Power-Plant for the Bristol Brabazon. J. L. Norton. *Aircraft Engineering*, Vol. 23, No. 267, May, 1951, pp. 124–133, illus., cutaway drawings. Power-plant description; engine mounting and layout; testing program.

The Twin Centaurus Power Plant for the Bristol "Brabazon." I, II. J. L. Norton. *The Engineer*, Vol. 191, Nos. 4970, 4971, April 27, May 4, 1951, pp. 542, 543; 589–591; illus. (Abstract of a paper, Institution of Mechanical Engineers, April 20, 1951.)

Adapting Cyclones (Wright 7 and 9) for Copter Use. *Aviation Week*, Vol. 54, No. 20, May 14, 1951, pp 35, 36, illus.

The Smitsvonk Low Tension Capacity Ignition. W. Beye Smits. *De Ingenieur*, Vol. 63, No. 3, January 19, 1951, pp. V1–V9, illus. 1 reference. Reprint.

The Smitsvonk Low-Tension Capacity Ignition. W. Beye Smits. (*De Ingenieur*, Vol. 63, No. 3, January 19, 1951, pp. V1–V9.) *The Engineers' Digest*, Vol. 12, No. 4, April, 1951, pp. 110–113, 130, illus.

Manifold Pressure vs. RPM at Part Throttle. *United Aircraft Corp., Pratt & Whitney Aircraft Division, Manual of Engine Operation, Engine Operation Information Letter No. 22*, April 20, 1951. 4 pp., illus.

ROCKET (4)

Heat Transfer in Rocket Motors and the Application of Film and Sweat Cooling. R. H. Boden. *American Society of Mechanical Engineers, Transactions*, Vol. 73, No. 4, May, 1951, pp. 385–390, illus. 2 references. Distribution of heat transfer and the factors that influence it; experimental methods and equipment for investigating film cooling.

Fluctuations in a Spray Formed by Two Impinging Jets. Marcus F. Heidmann and Jack C. Humphrey. *U.S., N.A.C.A., Technical Note No. 2349*, April, 1951. 35 pp., illus. 5 references.

Investigation of the instability of the combustion process in rocket engines at frequencies of 1,000–4,000 cycles per sec. by studying the characteristics and patterns of the spray formed by two impinging jets.

Survey of Development of Liquid Rockets in Germany and Their Future Prospects. W. von Braun. *British Interplanetary Society, Journal*, Vol. 10, No. 2, March, 1951, pp. 75–80. 2 references.

Production (36)

A Warning Against Making Germany's Mistakes of Wartime Production of Aircraft. Woldemar Voigt. *SAE Journal*, Vol. 59, No. 5, May, 1951, pp. 19–21. (Excerpts from a paper: Working for Air Defense.)

Seat-Manufacture. II—Design Variations; Single-Passenger Chair Manufacture; Machine Pipe-Bending. L. G. Burnard. *Aircraft Production*, Vol. 13, No. 151, May, 1951, pp. 147–153, illus. 1 reference.

Design and construction standards for a good basic design as applied to a single-passenger seat; manufacturing details—subassembly breakdown, press-bending of the tubular frame, seat-frame and side-arm assembly, upholstery.

Hole Production Method for Airframe Parts. August Bringewald. *SAE Journal*, Vol. 59, No. 5, May, 1951, pp. 26–28, illus. (Based on a paper: German Aircraft Manufacturing Methods.)

Air-frame mass-production fabrication procedure in which all the detail air-frame parts, including rivet holes, were completed before assembly, making large jigs and fixtures unnecessary.

Optical Airframe Tooling, a New Assembly Technique. A. Kastelowitz. *Automotive Industries*, Vol. 104, No. 8, April 15, 1951, pp. 38–41, 122, 124, 126, 128, illus. Optical system, including telescope and collimator, accurately checks alignment of bolted joint assembly fixtures at Republic Aviation Corp.

Double Duty Technique Cuts Aircraft Handling Costs. E. R. Petoskey. *Automotive Industries*, Vol. 104, No. 9, May 1, 1951, pp. 44–46, 72, 76, illus.

Reduction of materials handling at Northrop Aircraft, Inc., by eliminating the transfer of components and assemblies. Equipment used to move components and assemblies also serves storage or assembly purposes.

Rubber-to-Metal Bonding; Ingenious Adaptation of the Redux-Bonding Process. *Aircraft Production*, Vol. 13, No. 151, May, 1951, pp. 131, 132, illus.

Copy-Machining; Operation and Application of the Monarch Air-Gage Tracer Mechanism. *Aircraft Production*, Vol. 13, No. 151, May, 1951, pp. 154–156, illus.

Surface Finish Standards, for Roughness, Waviness, and Lay, As Adopted by the Department of Defense. T. E. Cassey and J. W. Sawyer. *Machine Design*, Vol. 23, No. 5, May, 1951, pp. 137–140, illus.

Stretch Brake Cuts Forming Cost 90 Per Cent. *Aviation Week*, Vol. 54, No. 19, May 7, 1951, pp. 42–44, illus. A stretch-forming attachment for a 600-ton hydraulic press brake developed at Northrop Aircraft, Inc. The equipment is used to form the wing and tail leading-edge skins of the F-89.

Stress Analysis of Reverse Redrawing of Cylindrical Shells. S. Y. Chung. *Sheet Metal Industries*, Vol. 28, No. 289, May, 1951, pp. 453–458, illus. 3 references.

Planning and Aircraft Development. F. Olaf Thornton. *Royal Aeronautical Society, Journal*, Vol. 55, No. 485, May, 1951, pp. 303–322, illus.

Planning procedures are applied to the design development of a prototype aircraft; the planning covers the period from the initial design proposal up to the first flight. Methods, including charts, are presented for estimating development time, manpower needed, costs, and effect of design changes.

Aircraft Production Damage Control. Willis L. Nye. *Aero Digest*, Vol. 62, No. 5, May, 1951, pp. 30, 78–82, illus. Handling, package, and storage procedures that minimize damage to parts.

Aero Commander in Production. Tom Ashley. *Flight Magazine*, Vol. 35, No. 5, May, 1951, pp. 18–20, 36, 37, 40, 41, illus. Production procedure and equipment of the Aero Commander high-wing twin-engined 5-place all-metal airplane.

de Havilland Comet; Planning and Production Methods. I—Design and Production Liaison, Fuselage Tooling and Construction. H. Povey. *Aircraft Production*, Vol. 13, No. 151, May, 1951, pp. 134–141, illus., cutaway drawings.

Novel Production Process. H. Povey. *The Aeroplane*, Vol. 80, No. 2075, April 27, 1951, pp. 510–513, illus. (Summary of an R.Ae.S. lecture, April 12, 1951: Planning and Production Methods Used in the Construction of the de Havilland Comet.)

Comet Construction Methods. H. Povey. *Flight*, Vol. 59, No. 2205, April 27, 1951, pp. 500–503, illus. (Summary of an R.Ae.S. lecture, April 12, 1951: Planning and Production Methods Used in the Construction of the de Havilland Comet.)

Engineering Developments in Aircraft Production. T. E. Piper. *Automotive Industries*, Vol. 104, No. 10, May 15, 1951, pp. 34–38, 144, 146, illus. Tooling, forming, and fabricating apparatus and procedures for economical production.

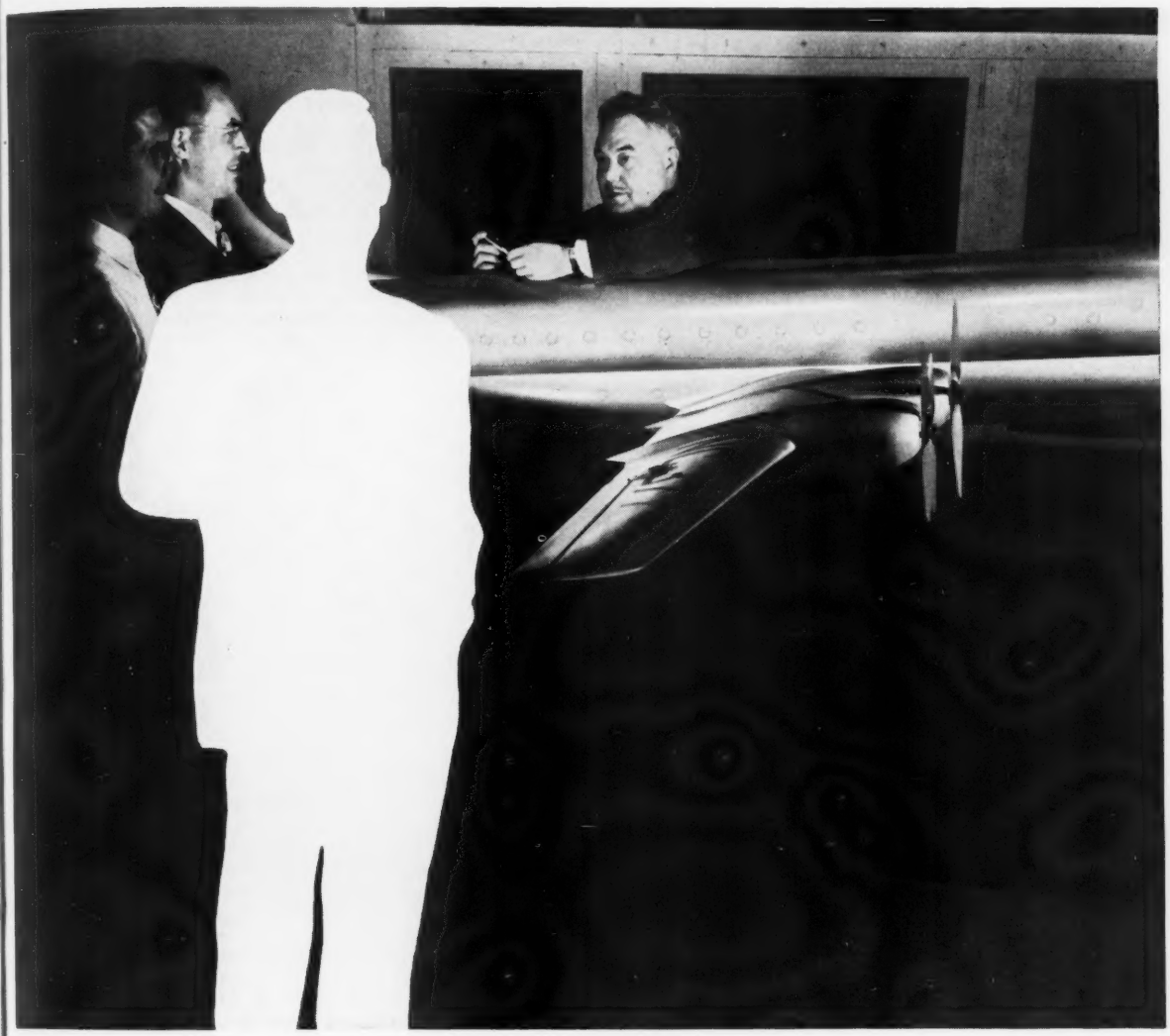
Propellers (11)

Tests on Thick Cuff Sections in the Compressed Air Tunnel. D. H. Williams and A. F. Brown. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2457*, 1951 (June 27, 1942). 8 pp., illus. British Information Services, New York. $0.50.

Tests on 40 and 50 per cent symmetric airfoils and a 40 per cent section with 10 per cent camber based on a cuff section near the boss of a propeller to investigate the effects of section aerodynamic characteristics on propeller cooling.

Investigation of the NACA 4-(3)(08)-03 and NACA 4-(3)(08)-045 Two-Blade Propellers at Forward Mach Numbers to 0.725 to Determine the Effects of Compressibility and Solidity on Performance. John Stack, Eugene C. Draley, James B. Delano, and Lewis Feldman. *U.S., N.A.C.A., Report No. 999*, 1950. 32 pp., illus. 7 references. Superintendent of Documents, Washington. $0.30.

Aerodynamic Balancing; Airscrew-Blade Integrating Machine Developed by Rotol Ltd. H. L. Milner. *Aircraft Production*, Vol. 13, No. 151, May, 1951, pp. 157–160 illus.



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Free-Space Oscillating Pressures Near the Tips of Rotating Propellers. Harvey H. Hubbard and Arthur A. Regier. *U.S., N.A.C.A., Report No. 996*, 1950. 21 pp., illus. 6 references. Superintendent of Documents, Washington. $0.25.

Development of a solution based on Gutin's equations for predicting the sound waves caused by a propeller and for predicting the oscillating pressures at any point in space. The theory is practical only in the region of the propeller blade tips. Experimental results demonstrate the validity of the theory. The fuselage response to these pressures is analyzed to study the problem of fuselage vibration and noise.

Propeller Blade Vibration: Nature and Severity of Vibration at Edgewise Resonance As Influenced by Coupling Effects Due to Blade Twist. J. F. Shannon and J. R. Forshaw. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2561*, 1950 (May, 1941). 10 pp., illus. 3 references. British Information Services, New York. $0.50.

Experiments on a 10-ft. 10-in. diameter de Havilland propeller mounted on a nonrotating torsionally elastic shaft system. Capacity-type strain gages gave stress-distribution curves for edgewise and second overtone flap resonance. A capacity element built as a seismic unit and a photographic apparatus were used to check the edgewise resonance results.

An Application of the Escalator Process. J. Morris. *Aircraft Engineering*, Vol. 23, No. 267, May, 1951, pp. 136, 137. 2 references. Method of solution of quasi-Hermitian frequency equations encountered in such problems as the whirling of contrarotating propeller systems and the mechanical vibration of aircraft.

Reference Works (47)

BIBLIOGRAPHIES

Selected Bibliography of Engineering Subjects. IV—Ceramic Engineering. *Engineers' Council for Professional Development*, 1951. 8 pp. List of 145 references, each with a descriptive annotation, classified under 15 headings.

Sampling of Ferrous and Non-Ferrous Alloys—A Bibliography. Albert C. Holler. *American Society for Testing Materials*, No. 174, May, 1951, pp. 66, 67. 52 references.

DICTIONARIES & ENCYCLOPEDIAS

English-French Vocabulary of Aeronautical Terms; Based upon British Standard 185: 1950, Glossary of Aeronautical Terms. II. M. Chalmette. *Aircraft Engineering*, Vol. 23, No. 267, May, 1951, pp. 145, 146.

Rotating Wing Aircraft (34)

Pulse-Jet Powered (American Helicopter Company, Inc.) XA-6 "Buck Private." G. F. Champlin. *American Helicopter*, Vol. 22, No. 5, April, 1951, pp. 8, 12, 13, illus.

Bristol Finishing Prototype 173 Copter. *Aviation Week*, Vol. 54, No. 19, May 7, 1951, pp. 21, 22, 25, illus., cutaway drawings.

Two-Place Helicopter at a Four-Figure Price (Hiller Hornet). Frank Coleman. *American Helicopter*, Vol. 22, No. 5, April, 1951, pp. 10, 11, 13, illus.

McCulloch MC-4 (Tandem Rotor Two-Place Helicopter). M. Berry. *American Helicopter*, Vol. 22, No. 5, April, 1951, pp. 6, 7, 12, illus.

Adapting Cyclones (Wright 7 and 9) for Copter Use. *Aviation Week*, Vol. 54, No. 20, May 14, 1951, pp. 35, 36, illus.

The Disturbed Motion of Articulated Blades. H. Roberts. *Gt. Brit., Aeronautical Research Council, Helicopter Committee, Report No. 12,688-H.127*, October, 1949. 77 pp., illus. 16 references. (Chapters V, VI, and VII from a Dissertation for the Diploma of the Imperial College.)

A Tested Solution of the Problem of Helicopter Stability and Automatic Control. Donald N. Meyers, Edward G. Vanderlip, and P. Halpert. *Aeronautical Engineering Review*, Vol. 10, No. 7, July, 1951, pp. 27–32, illus. Performance evaluation of the Piasecki XHJP-1 under automatic control with a Sperry A-12 gyropilot.

An Introduction to the Physical Aspects of Helicopter Stability. Alfred Gessow and Kenneth B. Amer. *U.S., N.A.C.A., Report No. 993*, 1950. 14 pp., illus. 6 references. Superintendent of Documents, Washington. $0.20.

Sciences, General (33)

MATHEMATICS

Tables of the Theodorsen Circulation Function for Generalized Motion. Yudell L. Luke and Max A. Dengler. *Journal of the Aeronautical Sciences*, Vol. 81, No. 7, July, 1951, pp. 478–483, illus. 18 references. Tables for generalized and harmonic motion; significance of the $C(k)$ function.

An Application of the Escalator Process. J. Morris. *Aircraft Engineering*, Vol. 23, No. 267, May, 1951, pp. 136, 137. 2 references.

Method of solution of quasi-Hermitian frequency equations encountered in such problems as the whirling of contrarotating propeller systems and the mechanical vibration of aircraft. The escalator process is based essentially on the successive introduction or elimination of each of the variables involved by definite self-contained stages in which the roots and modes of say a fourth-order set of equations are obtained in terms of those of the preceding third-order equations and vice versa.

Method of Successive Approximations for the Solution of Certain Problems in Aerodynamics. M. E. Shvets. (*Prikladnaia Matematika i Mekhanika*, Moscow, Vol. 13, No. 3, 1949, pp. 257–266.) *U.S., N.A.C.A., Technical Memorandum No. 1286*, April, 1951. 20 pp., illus. 8 references. Approximate solution of boundary-layer problems.

Criteria for Discrete Spectra. K. O. Friedrichs. *Communications on Pure and Applied Mathematics*, Vol. 3, No. 4, December, 1950, pp. 439–449. 9 references. Analysis of the nature of the spectra of differential operators of the second order; extension of the analysis to partial differential operators.

Wiener-Hopf Techniques and Mixed Boundary Value Problems. S. N. Karp. *Communications on Pure and Applied Mathematics*, Vol. 3, No. 4, December, 1950, pp. 411–426, illus. 13 references.

Differential Analyzer Uses Plug-In Units. C. D. Morrill. *Electronics*, Vol. 24, No. 6, June, 1951, pp. 222, 224, 226, 228, 230, illus. The Goodyear Electronic Differential Analyzer GEDA uses plug-in type multiplier units; a set of components can be easily arranged for a set of specific conditions.

SEAC Demonstrates High Reliability. *U.S., National Bureau of Standards, Technical News Bulletin*, Vol. 35, No. 5, May, 1951, pp. 72–74, illus. Report on operation of the N.B.S. computer (S.E.A.C.) for 1950.

A Method of Gating for Parallel Computers. A. G. Ratz and V. G. Smith. *Electrical Engineering*, Vol. 70, No. 5, May, 1951, p. 424, illus. Gating procedure that is applicable to all types of parallel computers; speeds of $^1/_2$ to 1 microsec. are obtained.

Applications of a Mechanical Differential Analyzer to Electrical Engineering. Earl Janssen and Don Lebell. *Electrical Engineering*, Vol. 70, No. 5, May, 1951, pp. 432–435, illus. 6 references.

PHYSICS

Readers' Forum: On the Velocity of Sound in Fluids. C. Truesdell. *Journal of the Aeronautical Sciences*, Vol. 18, No. 7, July, 1951, p. 501. 15 references.

Silicon-Monoxide Films As Replica and Supporting Membranes. Georg Hass. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 16, No. 5, May, 1951, p. 8, illus. For electron microscope and electron diffraction studies.

Structures (7)

The Behaviour of Framed Structures Under Repeated Loading. B. G. Neal. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 4, Part 1, March, 1951, pp. 78–84, illus. 9 references.

Analysis of framed structures with rigid joints which carry loads because of the resistance of the members to flexure; failure may occur by the establishment of a cycle of plastic deformation. The shake-down theorem is established to explain the behavior of such structures under variable loads.

The Compatibility Conditions for Large Strains. A. S. Lodge. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 4, Part 1, March, 1951, pp. 85–93. 7 references.

Qualitative analysis of the validity of the compatibility conditions derived (as by Weisenberg) for describing large strains.

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A Numerical Approach to the Instability Problem of Monocoque Cylinders. Bruno A. Boley, Joseph Kempner, and J. Mayers. *U.S., N.A.C.A., Technical Note No. 2354*, April, 1951. 45 pp., illus. 20 references. Calculation of the buckling load of monocoque cylinders with the use of tables based on the solution of a 14-row or a 10-row determinant.

On the Problem of Shear Lag in Non-Uniform Cylindrical Tubes. W. H. Wittrick. *Australia, Department of Supply, Aeronautical Research Laboratories, Report No. SM. 164*, January, 1951. 27 pp., illus. 1 reference.

Analysis of the stresses in a right-cylindrical tube of arbitrary, nonuniform cross section and of arbitrary load distribution. Two integral equations relating shear and direct stresses are derived which form a basis for solution by successive approximations. The results are concerned with the distributed shear lag effect and the derivation of a basic stress system.

Torsional Strength of Stiffened D-Tubes. E. S. Kavanaugh and W. D. Drinkwater. *U.S., N.A.C.A., Technical Note No. 2362*, May, 1951. 47 pp., illus. 9 references. Tests on D-tubes of alclad 24S-T3 aluminum alloy stiffened with ribs and stringers.

Failure of Cylindrical Tubes Under External Pressure. R. C. C. Ringrose. *Aircraft Engineering*, Vol. 23, No. 267, May, 1951, p. 138. 4 references. Analysis of failure under pure tension, compression, flexural instability, and elastic instability.

General Plastic Behavior and Approximate Solutions of Rotating Disk in Strain-Hardening Range. M. H. Lee Wu. *U.S., N.A.C.A., Technical Note No. 2367*, May, 1951. 56 pp., illus., folding chart. 14 references.

Derivation of a partly linearized solution for the plastic deformation of a rotating disc, based on the deformation theory of plasticity and the finite strains developed in the disc. Two methods are presented for investigating general plastic behavior of a rotating disc. Numerical calculations, based on these methods, agree well with experiment.

A Note on the Tensile Strength and Elongation of Wide Plates of Aluminium Alloy with and Without Holes. H. E. Smith and H. L. Cox. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2429*, 1951 (August, 1944). 8 pp., illus. British Information Services, New York. $0.50.

Test procedure and results to determine the effects of small holes on the tensile strength of aluminum alloy sheet and to assess holes reinforced with cover rings and with pressed flanges.

The Quadrilateral "Shear" Panel. S. J. Garvey. *Aircraft Engineering*, Vol. 23, No. 267, May, 1951, pp. 134, 135, 144, illus. Analysis of the stress and strain energy in a general uniform quadrilateral (wing) panel in equilibrium and loaded tangentially along its edges.

Achromatization of Debye-Scherrer Lines. Hans Ekstein and Stanley Siegel. *U.S., N.A.C.A., Technical Note No. 2355*, April, 1951. 23 pp., illus. 4 references. Investigation of a system that projects an achromatized and reduced image of the source upon a film for X-ray diffraction studies.

The Estimation of Wing Weight. J. Solvey. (*Australia, Department of Supply, Aeronautical Research Laboratory Structures and Materials Technical Memorandum No. 26.*) *Aircraft Engineering*, Vol. 23, No. 267, May, 1951, pp. 143, 144, illus. 4 references.

A method of predicting structural weight by relating the design to an ideal wing. A statistical analysis of actual wing weights yields correction factors, which, when multiplied by the ideal weight, give the estimated weight.

Thermodynamics (18)

Les Aspects Fondamentaux de la Thermocinétique. I—Théorie. Pierre Vernotte. *France, Ministère de l'Air, Publications Scientifiques et Techniques, Notes Techniques No. 41*, 1951. 45 pp. Service de Documentation et d'Information Technique de l'Aéronautique, Paris. 325 fr. In French. Fundamental aspects of thermokinetics (study of the move-

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ment of heat): basic theory, applications, and methods of calculation.

Fluid Dynamics of Energy Release. D. G. Samaras. (*Illinois University, Fluid Dynamics Panel, Lecture*, February 27, 1951.) *U.S., Office of Air Research*, 1951. 29 pp., illus. 25 references.

Summary of present knowledge of the theory of energy release. Continuous energy release in a duct, energy release in a wave front, deflagration, detonation, spinning detonation, and vorticity are analyzed briefly.

Readers' Forum: A Possible Relation Between Cellular Flame Structure and Quenching. Raymond Friedman. *Journal of the Aeronautical Sciences*, Vol. 18, No. 7, July, 1951, p. 499. 4 references.

Effect of Initial Mixture Temperature on Flame Speed of Methane-Air, Propane-Air, and Ethylene-Air Mixtures. Gordon L. Dugger. *U.S., N.A.C.A., Technical Note No. 2374*, May, 1951. 30 pp., illus. 21 references. Initial mixture temperature range, 34°–344°C.

A Method of Calculating the Temperature Distribution in Non-Uniformly Heated Tubes. F. Salzmann. (*International Congress for Applied Mechanics, 7th*, 1948, Vol. 3.) *Escher Wyss News*, Vol. 21–22, 1948–1949, pp. 22–27, illus. 1 reference.

A method is derived for the temperature distribution of a tube subjected to external radiations. This method is extended to the case of an actual flow taking place across the tube outer surface with the heat-transfer coefficient varying along the tube periphery. Reflection of the tube is neglected; it is assumed that the temperature variations do not disturb the uniformity of flow within the tube itself. Several examples illustrate the calculation procedure.

A Problem in Heat Conduction. Boris Podolsky. *Journal of Applied Physics*, Vol. 22, No. 5, May, 1951, pp. 581–585. Analysis of the temperature distribution of a fixed point source of heat that is moving in a homogeneous, isotropic, and infinitely extended fluid.

Water-Borne Aircraft (21)

The Future of the Seaplane. F. H. Robertson. *Shell Aviation News*, No. 154, April, 1951, pp. 14–19, illus.

The Seaplane in the U.S. Coast Guard. D. B. MacDiarmid. *S.A.E., National Aeronautic Meeting, April 16–19, 1951, Preprint No. 607*. 7 pp., illus. Advantages of a seaplane for rescue work; design and performance requirements for a seaplane that will give maximum rescue efficiency.

Variations on a Theme. P. R. Dowden. *New Slipway*, Vol. 2, No. 3, May, 1951, pp. 3–6, illus. Brief review of the development of flying-boat floats.

Water-Landing Investigation of a Model Having Heavy Beam Loadings and 0° Angle of Dead Rise. A. Ethelda McArver. *U.S., N.A.C.A., Technical Note No. 2330*, April, 1951. 19 pp., illus. 2 references.

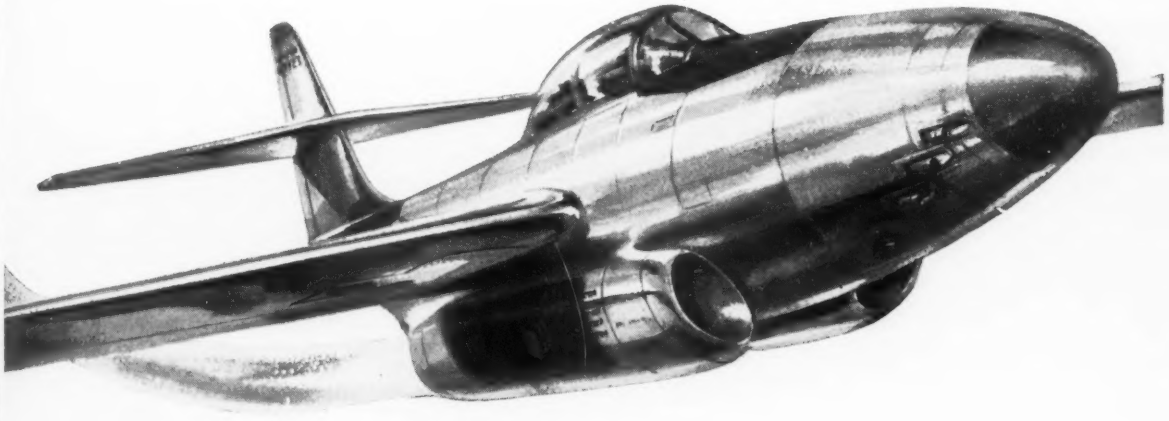
Wind Tunnels & Research Facilities

Free-Flight Air-Drag Measurement Techniques. A. B. J. Clark and Fred T. Harris. *U.S., Naval Research Laboratory, Washington, Report No. 3727*, September 6, 1950. 19 pp., illus. 1 reference.

Measurement technique and equipment of the ballistic-pendulum method of obtaining air drag coefficients of missiles at high Mach Numbers. The apparatus was used to determine the drag coefficient of 50 cal. spheres at $M = 1.4$ to $M = 5.4$. Both conventionally suspended pendulums and pendulums having seismographic suspension were used.

Environmental Testing Intensified by the USAF. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 16, No. 6, June, 1951, pp. 7–10, illus.

Testing Air Force materiel under simulated or natural climate and environments. Standard test procedures and apparatus were devised. Tests include high- and low-temperature conditions (−65° to 160°F.), temperature shock, humidity, altitude



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Resonance Sound Absorber with Yielding Wall. S. N. Rzhevkin. (*Zhurnal Teckhnicheskoi Fiziki*, U.S.S.R., Vol. 16, No. 4, 1946, pp. 381–394.) *U.S., N.A.C.A., Technical Memorandum No. 1273*, May, 1951. 26 pp., illus. 15 references.

Investigation of a single-sheet resonance system for normal incidence of sound to study the effect of sympathetic vibration of the resonator front wall on sound absorption. Formulas are derived for accurately computing the behavior of the system.

Current Projects in Aerodynamics Laboratory, Aircraft and Allied Instrument Laboratory, Flight Research Section, Fuels and Lubricants Laboratory, Gas Dynamics Section, Hydraulics Laboratory, Low Temperature Laboratory, and Structures Laboratory. *Canada, National Research Council, Aeronautical Laboratories, Quarterly Bulletin, Report No. ME 1951 (1)*, January 1–March 31, 1951, pp. 5–23, illus.

Report on Observations of the Behaviour of a Family of Plastic Wing Models Under Dead Weight and Aerodynamic Loads. A. H. Hall. *Canada, National Research Laboratories, Division of Mechanical Engineering, Structures Section, Report No. MM-222*, May 4, 1950. 26 pp., illus. 3 references.

Wind-tunnel studies of general aeroelastic phenomena using rectangular-wing models made of cellulose acetate to investigate the suitability of cellulose acetate for model construction and the structural behavior of such models. Results of static loading tests showed that the cellulose acetate models did not give accurate and repeatable measurements of deformation when the forces varied in duration.

The Air Flow Under the Towing Carriages in the R.A.E. Seaplane Tank. K. M. Tomaszewski, S. Raymond, and G. F. Chalmers. *Gt. Brit., Aeronautical Research Council, Current Papers No. 38 (Technical Note No. Aero.1793)*, 1951 (June, 1946). 30 pp., illus. 4 references. British Information Services, New York. $1.00. Analysis of the effect of airflow upon the measurements of flow around the model; construction and testing of flaps to reduce this air speed.

On the Second-Order Tunnel-Wall-Constriction Corrections in Two-Dimensional Compressible Flow. E. B. Klunker and Keith C. Harder. *U.S., N.A.C.A., Technical Note No. 2350*, April, 1951. 23 pp., illus. 11 references.

Development of an integral representation for tunnel-wall interference (constriction) which is based on solutions for the subsonic flow past thin, sharp-nosed, symmetric, two-dimensional bodies in closed channels. The solution is applied to evaluating the wall-interference effects for a symmetric parabolic-arc airfoil. Constriction effects for an open tunnel may be obtained by a similar analysis.

The Effect of Model Size on Measurements in the R.A.E. High Speed Tunnel. Drag of Two-Dimensional Symmetrical Aerofoils at Zero Incidence. W. A. Mair and H. E. Gamble. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2527*, 1951 (December, 1944). 15 pp., illus. 5 references. British Information Services, New York. $0.75.

Pitot-traverse drag tests in the R.A.E. high-speed wind tunnel to evaluate blockage corrections. The difference in Reynolds Number between tunnel and flight measurements and the effect of the tunnel walls were studied.

Flow in a Shock Tube of Non-Uniform Cross-Section. J. Lukasiewicz. *Canada, National Research Laboratories, Division of Mechanical Engineering, Supersonics and Gas Dynamics Section, Report No. MT-11*, January 18, 1950. 18 pp., illus.

Analysis of the flow following the bursting of a diaphragm that separates gases at different pressures. The initial pressure ratio for a flow at a given Mach Number or a shock of given intensity is determined.

Axial Blowers for Wind Tunnels. W. Gaehler. *Escher Wyss News*, Vol. 21–22, 1948–1949, pp. 13–21, illus. 4 references. Wind-tunnel design procedures; description of wind tunnels at the Technical Section of the Swiss Federal Military Department.

Ejector Theory and Its Application to Induction Type Wind Tunnels. W. R. Laidlaw. *Canada, National Research Laboratories, Division of Mechanical Engineering, Aerodynamics Laboratory, Report No. MA-232*, August 9, 1950. 55 pp., illus. 11 references.

Development of an ejector theory for the performance analysis of a gas-turbine-type wind tunnel. The problems of design and analysis of the gas-turbine wind tunnel are considered in detail to provide a basis for efficient design and analysis of induction tunnels of all types.

Shock Tube Theory and Applications. J. Lukasiewicz. *Canada, National Research Laboratories, Division of Mechanical Engineering, Supersonics and Gas Dynamics Section, Report No. MT-10*, January 18, 1950. 147 pp., illus. 33 references.

Development of the theory of shock-tube flow in a form adaptable for the aerodynamic design of shock tubes; tables and diagrams give the functions involved for any gas. The analysis covers the initial phase of shock-tube flow and the influence of the tube ends of the flow. Design of a shock tube for compressible flow studies illustrates the application of the theory. Some experimental results are given.

The Design of Fans and Guide Vanes for High Speed Wind Tunnels. W. A. Mair. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2435*, 1951 (June, 1944). 27 pp., illus. 13 references. British Information Services, New York. $1.25. Design procedure for fans and guide vanes for wind tunnels that have speeds greater than 300 ft. per sec.

A Three-Channel Piezo-Electric Pressure Recorder. P. J. Fletcher. *Gt. Brit., Aeronautical Research Council, Current Papers No. 35 (Memorandum No. M.64)*, 1951 (November, 1949). 12 pp., illus. 2 references. British Information Services, New York. $0.40. Design and operation of a recorder for cascade wake readings.

Electrical Analogy Methods for Studying the Flow of Fluids. W. F. Campbell. *Canada, National Research Council, Aeronautical Laboratories, Quarterly Bulletin, Report No. ME 1951(1)*, January 1–March 31, 1951, pp. 1–4, illus. 4 references.

Theory, apparatus, and application of the method for investigating fluid flow, assuming little or no viscosity. Pressure and velocity are measured by a thin-wire probe and a Wheatstone bridge.

Further Development of Fluid Mappers. A. D. Moore. *Electrical Engineering*, Vol. 70, No. 5, May, 1951, pp. 396–401, illus. 4 references. Types of fluid mappers; construction; limitations; explanation of problems and their suggested solutions.

La Dynamomètrie et les Jauges a Fils Résistants Collés. E. Gaignebet. *La Recherche Aéronautique*, No. 20, March-April, 1951, pp. 27–35, illus. 14 references. In French.

Characteristics of resistance-wire strain gages; their application as an unidirectional dynamometer for a wind-tunnel balance capable of measuring loads up to 350 kg. with a maximum error of 150 grams.

Pont Statique de Pesées d'Avions. J. Laxague. *La Recherche Aéronautique*, No. 20, March-April, 1951, pp. 37–41, illus. In French.

Resistance-wire strain gage pressure cells are used with a modified bridge circuit for aircraft weighing. Two of the pressure cells can detect loads up to 10 tons (metric); the third, up to 2 tons (metric). A precision of 0.3 per cent can be obtained with loads of 700 kg.

Les "Jauges" Montées sur la Balance S.G.S. de la Soufflerie S7 L. Ch. du Laboratoire de Mécanique des Fluides. Jean Le Gallo. *La Recherche Aéronautique*, No. 20, March-April, 1951, pp. 47–51, illus. In French. Resistance-wire strain gages as used in the S.G.S. balance of the S7 L. tunnel of the Laboratory of Fluid Mechanics.

Utilisation en Soufflerie d'Anneaux Dynamomètriques à Jauges Extensomètriques Collées. A. Ravailhe. *La Recherche Aéronautique*, No. 20, March-April, 1951, pp. 53–60, illus. In French. Wind-tunnel application of ring dynamometers with bonded wire-strain-gage extensometers; theory; design; measurement procedure; test results.

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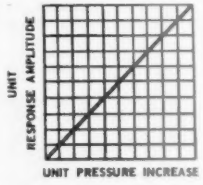

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Aeronautical Reviews — BOOKS

Introduction to the Study of Aircraft Vibration and Flutter

By Robert H. Scanlan and Robert Rosenbaum. New York, The Macmillan Company, 1951. 428 pp., figs. $7.50.

Although the title of this book indicates that it is intended to cover only vibration and flutter, it is actually a fairly comprehensive introduction to the area that has commonly been called aeroelasticity. In this sense, it is the first textbook to appear which deals with this broad field.

An engineer practicing in the field of aeroelasticity, as the title implies, requires a rather complete knowledge of the heretofore separate fields of aircraft structures and aerodynamics. In addition, he must know the various recipes for combining the two separate ingredients to reproduce the mixture that is represented by his problem. Perhaps it is largely the latter knowledge that places the field of aeroelasticity in the category of an art. Here the aeroelastician must summon all the resources at his command in order to formulate the problem to obtain a meaningful answer. He must be guided by past experience, flight-test data, model tests, mathematical analyses, and engineering judgment. He cannot surrender completely to the mathematician nor can he rely on any single experimental tool. Finally, the practicing aeroelastician must have an appreciation of testing techniques and instrumentation.

Generally speaking, the authors have at least touched on all of these important aspects that can be treated in a textbook. Their philosophy has properly been one of emphasizing fundamentals and preparing the reader to read the extensive literature on the state of the art, as well as to develop his own initiative in solving new problems, rather than one of teaching him to fill in the latest tables promulgated by the Government agencies.

The book is not intended as an exhaustive treatise, but its purpose is introductory, aimed at serving two types of readers; the practicing engineer in the field who is not familiar with modern techniques, and engineering students in their senior and graduate years.

The first chapter covers basic mathematical methods. This is extremely well done and includes among other things a comprehensive treatment of matrix algebra, methods of solving linear equations, and methods of finding the roots of high-degree polynomials. It has been the reviewer's experience that a need for these techniques arises continually in vibration and aeroelastic problems. The next four chapters cover the fundamentals of dynamics. This includes Lagrange's equation, normal coordinates, complex-variable techniques in vibrations, self-excited oscillations, and stability criteria. The reviewer was pleased to see the stress placed by the authors on the importance of the Lagrangian points of view in problems in advanced dynamics.

Chapters VI and VII deal entirely with the structural aspects of aircraft vibration and aeroelastic problems. The emphasis is, of course, on beams with the usual development of the engineering theory of bending and torsion. In addition, the authors include some recent contributions such as Levy's method of determining influence coefficients. A complete treatment of beam vibrations is given.

The next three chapters introduce the two-dimensional flutter theory and then extend it to three-dimensional theory and empennage flutter analyses. The mechanical terms are derived by means of Lagrange's equation, and the structural damping is introduced by a dissipation function. Formulas for the aerodynamic forces and moments are given, and the reader is referred to an appendix for their derivation. In these developments the reader is taken no further than the stability determinant, and he is referred to a later chapter which deals exclusively with methods of solution of the stability determinant. This later chapter contains several of the recent and most popular methods. Since this is a topic in which many engineers have been prolific during the past decade, it is obviously impossible for the authors to provide an exhaustive treatment.

Chapter XIV is devoted to the important static aeroelastic problems of wing torsional divergence, aileron reversal, and aileron effectiveness. The authors discuss these problems first from the point of view of two-dimensional aerodynamics and strip theory, and then the important three-dimensional aspects are introduced.

Subsequent chapters discuss vibration and flutter test procedures, including instrumentation and some aspects of swept-wing problems. The authors have wisely included some remarks on the matter of flight flutter testing and the usefulness of dynamic models.

The appendix is in six parts and is devoted entirely to aerodynamic considerations. The longest part is naturally the derivation of the subsonic incompressible theory of the forces on an oscillating airfoil in two dimensions. This is followed by derivations of Wagner's function and Kussner's function and discussions of oscillating airfoils in subsonic compressible and supersonic flow. Finally, a complete table of aerodynamic coefficients is given for the supersonic and incompressible cases. It is on the aerodynamic aspects of the book that the reviewer believes the authors could have placed greater emphasis. This is especially true from the point of view of the teacher who is faced with the problem of introducing students to unsteady aerodynamics for the first time in connection with the flutter problem. It is perhaps these topics more than any others to which the authors refer when they state that with some regrets they have not heavily emphasized certain topics to which decided emphasis has been given in the literature largely because of the nature of their own particular experience rather than an intention to slight such material.

Because of the recognized standing of the authors in the field and because this book at last fills a need that has long existed, it merits the attention of

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Statements and opinions expressed in Book Reviews are to be understood as individual expressions and not necessarily those of the Institute.

everyone working in the fields of aircraft vibrations and aeroelasticity.

R. L. BISPLINGHOFF
Associate Professor of
Aeronautical Engineering
Massachusetts Institute of Technology

Miracle at Kitty Hawk

The Letters of Wilbur and Orville Wright. Edited by Fred C. Kelly. New York, Farrar, Straus and Young, 1951. 482 pp., illus. $6.00.

Fred C. Kelly, official biographer of the Wright Brothers, has selected over 300 of their letters and liberal excerpts from their diaries for this book. It is an important contribution to the history of aeronautics, supplying a source record for the first ten years of controlled heavier-than-air flight, which is of inestimable value.

The letters of their boyhood were few, and the record may be said to begin with Wilbur's letter of May 30, 1899, to the Smithsonian Institution, where he says, "I am about to begin a systematic study of the subject in preparation for practical work to which I expect to devote what time I can spare from my regular business." In his first letter to Octave Chanute, on May 13, 1900, he stated, "It is possible to fly without motors, but not without knowledge and skill." Writing to his father on September 23, 1900, he said, "When once a machine is under control under all conditions, the motor problem will be quickly solved."

By the summer of 1901, the first published record of their experiments appeared—"Die wagerechte Lage während des Gleitfluges," Wilbur's contribution to *Illustrierte Aeronautische Mitteilungen*, Vol. 5, July, 1901, translated into German—which indicated, without details, that a mechanical solution to the problem of stability had been found. Wilbur went into more detail on stability and control in his letter of November 16, 1900, to Octave Chanute. But the pattern of their investigations is already in the record, and their amazing engineering achievement has been thoroughly appraised by engineers and historians. It was a matter of building a glider and learning to fly it, improving its performance through wind-tunnel testing methods, then constructing an engine, designing propellers, and installing the power plant. Then they flew it. After that they made turns with it and flew circles.

The source material in this book amplifies the record and, so to speak, makes it official. These letters were not previously available. The Wright papers in the Library of Congress, of which they form a part, will not be generally available until 1960. Mr. Kelly's notes, some from Carrie Kayler Grumbach who was with the Wright family from 1900 to 1948, add many interesting details to the record.

The personalities of the brothers emerge more fully than before. Wilbur was likely to forget his hat and had to be reminded to press his trousers. He wore Orville's shirt, collar, cuffs, cuff links, and overcoat when he went to address the Western Society of Engineers. He stuffed the Wright turkey at Christmas but was less particular about food than Orville. Orville never forgot his hat but teasingly measured the cook as she grew. When he teased her too much, a word from Wilbur stopped him. "Mr. Orville always listened to Mr. Will, but *never* to anyone else."

Wilbur wrote over 225 of these letters, and Orville wrote about 70. Naturally, both wrote more when they were at Kitty Hawk or in Europe, and there was considerable correspondence between them when the brothers were separated. In 1908 Wilbur wrote 61 letters and Orville 21. Wilbur largely kept up the correspondence with Octave Chanute, George A. Spratt, and others and carried the burden of testifying during the patent suits. (There are 18 letters from Octave Chanute in this book.)

However, as Mr. Kelly points out (pp. 123–124), the brothers supplemented each other. One made a move, and the other took the next step. "Neither one could or would have solved the problem alone."

MAURICE H. SMITH
Librarian, I.A.S.

Book Notes

AIR TRANSPORTATION

High Horizons; Daredevil Flying Postmen to Modern Magic Carpet—The United Air Lines Story. Frank J. Taylor. New York, McGraw-Hill Book Company, Inc., 1951. 198 pp., illus. $4.00.

The twenty-five years from 1926 to 1950 form the main period of this history. It is the history of United Air Lines, Inc., and its predecessor companies, but, in describing the evolution of a typical large operation, the author goes back to the first contract air-mail services, the first coast-to-coast air-mail service, and the first night mail flights. The development of the transport airplane, airways, navigation aids, airports, instruments, and operating know-how are historical accompaniments. There is a great deal of useful information on pilots and others who made their contributions and the book is well illustrated. There is a chronology, but no index.

ELECTRONICS

High-Frequency Measurements. August Hund. 2nd Ed. New York, McGraw-Hill Book Company, Inc., 1951. 676 pp., diagrs. $10.

This edition of an advanced textbook and reference book originally published in 1933 is larger by 185 pages and has been revised to cover the entire useful range of radio frequencies from low to superhigh frequencies. Audio-frequency-current procedures are included. The chapters on Line and Antenna Determinations and Modulation Measurement have been completely rewritten, and material on bridge methods of measurement has been added, including radio-frequency and very-high-frequency (V.H.F.) bridges. Footnote references are included throughout, and there is a detailed index of subjects and names. The author was formerly with the National Bureau of Standards and is now a scientific and technical radio consultant.

Waveguide Handbook. Edited by N. Marcuvitz. (Massachusetts Institute of Technology, Radiation Laboratory Series No. 10.) New York, McGraw-Hill Book Company, Inc., 1951. 421 pp., illus., diagrs. $7.50.

The author's main purpose is to present the equivalent-circuit parameters for a large number of microwave structures as reformulations of microwave field problems into microwave network problems. Theoretical considerations of both the field and network points of view are introduced in the first three chapters on Transmission Lines, Transmission Line Modes, and Microwave Networks, leading into some of the field theoretical methods employed in the derivation of the equivalent-circuit parameters discussed in Chapters 4 to 8. These chapters cover two-, four-, six-, and eight-terminal structures and composite structures. Results are presented both analytically and graphically. The editor is Associate Professor of Electrical Engineering at the Polytechnic Institute of Brooklyn.

Vacuum-Tube Voltmeters. John F. Rider and Alfred W. Barber. 2nd Ed. New York 13, N.Y., John F. Rider Publisher, Inc., 1951. 422 pp., diagrs. $4.50.

This book was first published in 1941. The present edition is larger by 243 pages and reflects advances in vacuum-tube voltmeters of all types in the last ten years. The first seven chapters cover diode, triode, rectifier-amplifier, tuned, amplifier-rectifier, and slide-back voltmeters. Vacuum-tube-voltmeter probes and various commercial voltmeters are discussed in separate chapters, and there are chapters on applications, design and construction, calibration and testing, and maintenance and repair. A bibliography of over 200 references is included.

Television and F M Antenna Guide. Edward M. Noll and Matthew Mandl. New York, The Macmillan Company, 1951. 311 pp., illus., diagrs. $5.50.

In the first part (118 pages) the basic principles of wave propagation, antenna characteristics, and system performance are presented in textbook form. Review questions and bibliographies are included. The second part is designed as a practical handbook on antennas and their installation, including step-by-step procedures, dimensions, gain and impedance figures, and performance data on commercial antenna types. The senior author is Television Instructor at the Technical Institute of Temple University, and Mr. Mandl is Director of Radio Courses and a lecturer on electronics and television there.

EQUIPMENT

ELECTRIC

Synchronous Machines, Theory and Performance. Charles Concordia. New York, John Wiley & Sons, Inc., 1951. 224 pp., diagrs. $5.50.

The primary object of the author is to present a unified development of the fundamental circuit theory of the transient performance of synchronous machines as currently used by engineers directly concerned with the prediction of machine performance. The mathematical development and the behavior of synchronous machines from the physical point of view are emphasized. There are 76 references in the bibliography from about 1913 to date. The book grew out of a synchronous-machine course given at the General Electric Company by the author, who is associated with the Analytical Engineering Department.

FLIGHT SAFETY & RESCUE

Handbook for Aircraft Accident Investigators Cooperating in Crash Injury Research (CIR H-2). New York, Cornell University Medical College, Crash Injury Research, 1951. 54 pp., illus., diagrs.

Crash Injury Research is sponsored by the Departments of the Navy and the Air Force and by the Civil Aeronautics Administration. It acts under advisement of a joint Navy-Air Force Advisory Committee and operates under the auspices of the Cornell Committee for Air Safety Research. Accident reports from state and federal investigating groups are essential to its objectives. This handbook is intended as a guide for personnel who investigate aircraft accidents and report accident-injury details to Crash Injury Research. Because accurate reports are essential to the drafting of recommendations for modifying dangerous features in aircraft, the use of the Crash Injury Research Form AC is discussed in considerable detail. The Classification of Aircraft Accidents, Procedure at the Scene of an Accident, General Accident Data, Details of Aircraft Damage, and Injury Details are the principal chapter headings.

FUELS & LUBRICANTS

The Chemistry of Hydrazine. L. F. Audrieth and Betty Ackerson Ogg. New York, John Wiley & Sons, Inc., 1951. 244 pp., diagrs. $5.00.

This is a revision of a report of the same title which appeared in April, 1949, under the sponsorship of the Office of Naval Research. The discovery of the Germans during World War II of the properties of hydrazine as a fuel led to research, which is being continued, on its behavior and synthesis. The present survey covers the literature published on it since its discovery 60 years ago and discusses the relation of hydrazine to other hydronitrogens, methods of its preparation and formation, including theories, its oxidation, use as a reducing agent, qualitative identification and quantitative determination, simple and double salts, anhydrons hydrazine as a solvent, and the hydrazine system of compounds. A chapter is included on its uses in explosives, fuels, and propellants, as a reducing agent, as a solvent, and in plasticizers, softeners, resins, coatings, and adhesives. The authors are respectively Professor of Chemistry and Research Associate at the University of Illinois. Extensive lists of references are included at the ends of chapters.

Lubrication, Its Principles and Practice. A. G. M. Michell. London, Blackie & Sons, Ltd., 1950. 317 pp., diagrs. 35*s*.

The author's purpose is to provide a general account of lubrication and essential data and factual information as needed in practice by the operating engineer or designer. Since his primary aim is to assist practice, theory is principally included for its practical utility. Previously unpublished material is included in the discussions of Sliding Bearings, Journal Bearings, Rolling Bearings, and in the chapter on lubrication of gear wheels, worm gears, piston rings, and small pivot bearings. The physical properties of lubricants, typical modes of flow, and numerical constants of lubricating fluids are discussed in early chapters, and there is a separate chapter on Thrust Bearings and Some Other Sliding Bearings. Final chapters deal with the Distribution and Treatment of Lubricants in Service and Conveyance of Lubricants in Systems of Distribution and Circulation. A useful table of equivalent units is included, and there are 128 references arranged by chapters. The author has conducted an engineering practice in Melbourne since 1903.

INSTRUMENTS

Modern Interferometers. C. Candler. London, N.W. 1, Hilger & Watts Ltd., Hilger Division, 1951. 502 pp., illus., diagrs. 57*s*. 6*d*.

The author aims to provide a comprehensive discussion of the interferometers in use in industry, in the standardizing laboratory, and in research. The arrangement of chapters is according to the use of the interferometers for measurement of differences in optical path, length, wave length, or refractive index. Diffraction gratings are covered in a group of six chapters. Only essential theory is discussed, and the historical background is not surveyed separately. Numerous references are included chronologically at the ends of chapters; Russian papers are listed separately. Later papers are listed in an appendix, and indexes of authors and subjects are provided. The author has succeeded admirably in his aim, particularly for British, American, and German interferometers.

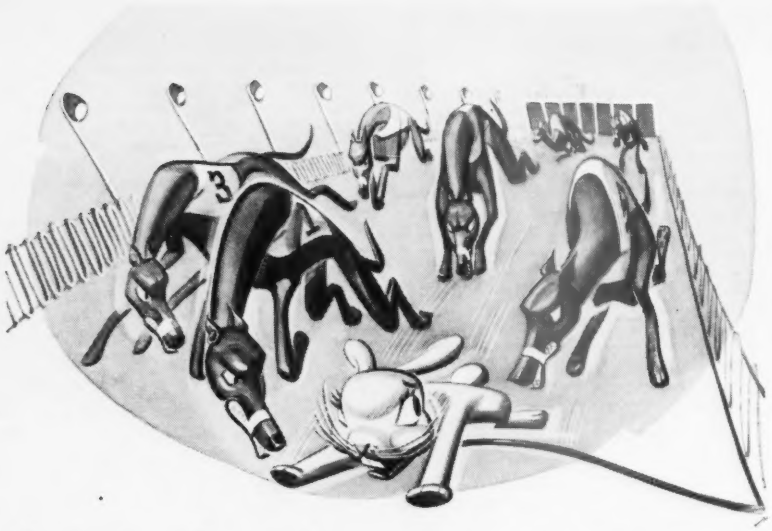
LAWS & REGULATIONS

Shawcross and Beaumont on Air Law. Christopher N. Shawcross, K. M. Beaumont, and Patrick R. E. Browne, Assisted by A. R. Paterson and R. Stuart Kinsey. London, Butterworth & Company (Publishers) Ltd.; Toronto, The Carswell Company, Ltd., 1951. 1,377 pp. $26.50.

The first edition of this book was completed late in 1944 and published in 1945. The present edition is larger by 561 pages and includes such major changes in English and international air law as the change from the Paris Convention System (1919) to the Chicago Convention System (1945), the Civil Aviation Act, 1949, and the Air Corporations Act, 1949. The book is up to date as of July 31, 1950, and includes the Convention on the International Recognition of Rights in Aircraft, 1948. The (1949) Conditions of Contract of the International Air Transport Association will be included in an early supplement. The *U.S. Aviation Reports* are referred to in appropriate sections. However, the American user will derive most benefit from the sections on international air law, including the texts of international conventions.

MACHINE ELEMENTS

Analysis of the Four-Bar Linkage, Its Application to the Synthesis of Mechanisms. John A. Hrones and George L. Nelson. New York,



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Published jointly by The Technology Press of the Massachusetts Institute of Technology and John Wiley & Sons, Inc., 1951. 752 pp., diagrs. Size: 11½ by 17½ in. $15.

Displacement trajectories of a network of points on the connecting rod of a four-bar linkage are presented for 146 link ratios in a series of 730 charts. Each trajectory consists of 72 dashes. The distance between corresponding points on adjacent dashes is equal to the displacement of the given point on the connecting rod for a 5° angular displacement of the driving crank. For each set of link ratios there are five charts, covering motion characteristics of a given linkage. The purpose is to give direct aid in the selection of a mechanism to produce a desired motion. Altogether, over 7,000 displacement paths are described graphically, representing about 500,000 solutions where the four-bar linkage can be applied. This basic mechanism is discussed, and the use of the charts is explained in the preliminary pages. The authors are respectively Professor and Assistant Professor of Mechanical Engineering at the Massachusetts Institute of Technology.

Practical Design of Mechanical Elements. American Society of Tool Engineers, Book Committee; Frank W. Wilson, Editor-in-Chief. New York, McGraw-Hill Book Company, Inc., 1951. 278 pp., illus., diagrs. $3.00.

This is a reprint of Sections 104 through 113 (pp. 1631–1908) of the excellent *Tool Engineers Handbook*, pulished in 1949. These sections cover Screw Threads; Gears; Splines and Serrations; Cams; Ball and Roller Bearings; Sleeve Bearings and Bushings; Springs; Keys, Keyways, and Shafts; Tapers, Spindle Noses, and Arbors; and Mechanics and Physics. Each section is written by a specialist. Bibliographies, tables of data, charts, and drawings are included.

MATERIALS

Creep of Metals. L. A. Rotherham. London, Institute of Physics, 1951. 80 pp., diagrs. 15s.

The progressive plastic extension occurring in metals subjected continuously to stress at high temperatures, as in jet engines, is discussed from the physical point of view. The characteristics of the creep curve, crystalline flow, metallographic features of creep, and grain boundary, transient, steady-state, and tertiary creep are taken up, with a final chapter on the development of creep-resistant alloys. A list of 81 references is included. The author was formerly Superintendent of the Metallurgy Department of the Royal Aircraft Establishment, Farnborough, and is now Chief Metallurgist to the Ministry of Supply, Division of Atomic Energy (Production).

Engineering Materials Manual. Edited by T. C. DuMond. New York 18, *Materials & Methods*, Reinhold Publishing Corporation, 1951. 386 pp., illus., diagrs. $4.50.

This volume consists of 28 "Materials and Methods Manuals" reprinted from the magazine, *Materials & Methods*. Five of them are concerned with standard, stainless, high-strength low-alloy, clad, tool, and free cutting steels. Grey-iron castings, wrought aluminum alloys, aluminum castings, magnesium alloys, bronzes and beryllium copper, and bearing metals are other metals discussed. Cemented carbides, ceramics, rubber, porcelain enamels, and industrial adhesives are discussed in separate sections. There are five sections on plastics, including a general outline, selection and applications, and separate sections on thermoplastics, thermosetting plastics, and plastic laminates. Hard-facing materials, organic finishes for metals, electroplated coatings, and coloring of metals are also discussed. Properties, availability, machining and production, and design considerations are considered in each section.

Nonmetallic Minerals. Raymond B. Ladoo and W. M. Myers. 2nd Ed. New York, McGraw-Hill Book Company, Inc., 1951. 605 pp. $10.

This useful reference book was first published in 1925. The present edition covers about 90 nonmetallic minerals or groups of minerals, including

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15 new ones, and has been completely revised and brought up to date. Typical minerals covered include abrasives, aluminum silicates, bauxite, beryllium minerals, lithium minerals, magnesite and magnesium compounds, refractories, titanium minerals, uranium, and zircon and zirconium minerals. The arrangement of material is uniform, covering composition, physical properties, occurrence in various parts of the world, mining and milling, utilization, bibliographies, tables of data on production and consumption in the United States, and world production. Price ranges are included. The senior author, a consulting engineer, was formerly associated with the U.S. Bureau of Mines. Dr. Myers is Chief of the Division of Mineral economics at The Pennsylvania State College.

NATURAL FLIGHT

De Vliegkunst in het Dierenrijk (The Art of Flying in the Animal Kingdom). E. J. Slijper. Leiden, Netherlands, E. J. Brill, 1950. 178 pp., illus., diagrs. $4.00. In Dutch.

PHOTOGRAPHY

Photographic Optics. Allen R. Greenleaf. New York, The Macmillan Company, 1950. 214 pp., diagrs. $4.75.

The author's purpose is to provide photographers with information for the approximate appraisal of the merits of various types of lenses without detailed mathematical computation. The principles of geometric optics are presented as needed for a qualitative explanation of the various aberrations of lenses, and methods for minimizing aberrations are outlined. The last half of the book is on photographic practice and various types of equipment. The choice and testing of lenses, focusing, shutters, camera accessories, estimation of exposure, perspective printing, slide projectors, and stereoscopy are among the topics discussed. There is a bibliography of 35 papers and books.

PRODUCTION

Defense Without Inflation. Albert G. Hart. New York, The Twentieth Century Fund, 1951. 186 pp. $2.00.

An overall analysis is made of full industrial mobilization, comparing the World War II situation with the present, with respect to goals, methods, controls, and policies. Recommendations are included on policies for stabilization of the civilian economy while aiming at the most effective defense.

Production Forecasting, Planning, and Control. E. H. MacNiece. New York, John Wiley & Sons, Inc., 1951. 305 pp., illus., diagrs. $5.50.

This textbook is designed for a one-semester course. The author's approach is from the engineering point of view, supplemented by material on social and economic implications. Practical experience in the solution of production problems is provided in 190 examples, and there are about 90 illustrative diagrams showing relationships between company departments, company and customers, and company and suppliers. Each chapter is summarized, and typical cases are discussed. The final three chapters deal with the complete forecasting, planning, and control of a business, the solution to this overall problem, and production planning for war production. The author is Director of Quality Control with Johnson and Johnson.

Principles and Methods of Sheet-Metal Fabricating. George Sachs. New York, Reinhold Publishing Corporation, 1951. 326 pp. diagrs. $10.

The many design and metal-forming methods resulting from extensive experience in aircraft and ordnance production and in other industries are organized systematically in this book. Part I takes up Sheet Metal and Sheet-Metal Parts, including metal properties, part design, and the design, layout, and preparation of blanks. Part II deals with Principles of Forming Various Part Types, covering bending and straight flanging,

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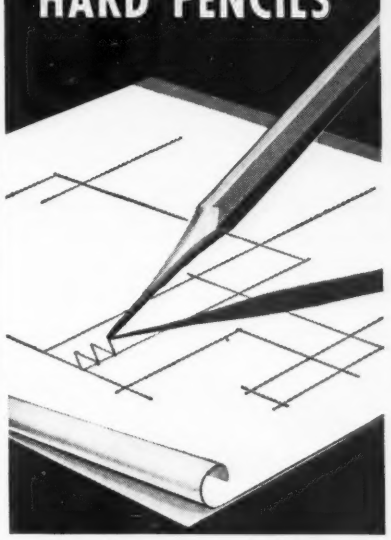

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contoured flanges, contour forming of sections, and deep and shallow recessed parts. The Principles of Deep Drawing are covered in Part III, including thin- and thick-walled cylindrical cups, sinking and ironing of tubular parts, and drawing of box shaped parts. Part IV takes up Press-Die Forming, covering equipment, tools, lubrication, forming from developed blanks, forming of recessed parts, cartridge-case forming, and impact extrusion and coining. Drop-hammer, rubber, stretch, and contour forming; roll bending and forming; and spinning are among the processes described in the final section. Bibliographies are included at the ends of chapters. The author is Vice-President of Horizons, Inc., Cleveland, and has been a consultant on aircraft and ordnance production problems.

Metal Processing. Orlan William Boston. 2nd Ed. New York, John Wiley & Sons, Inc., 1951. 763 pp., illus., diagrs. $7.50.

This textbook for mechanical and aeronautical engineering students was first published in 1941. The present edition is larger by 133 pages, with a new chapter on The Quality of Surface Finish and with considerable enlargement of the chapters on machinability and machine-tool drives, including electric motors and hydraulic pumps and their controls and circuits. New material on sintered-carbide tools and their use is included. Emphasis is placed particularly upon the nomenclatures for tools and upon machinability. Data are included on cutting forces, power, tool life, chip formation, and surface quality as related to the properties of the material being machined, the cutting fluid, and the shape and quality of the tool. The author is a Professor of Metal Processing and Chairman of the Department of Metal Processing at the University of Michigan.

Practical Design of Manufacturing Tools, Dies, and Fixtures. American Society of Tool Engineers, Book Committee; Frank W. Wilson, Editor-in-Chief. New York, McGraw-Hill Book Company, Inc., 1951. 230 pp., illus., diagrs. $2.75.

This is a reprint of Sections 96 through 100 (pp. 1,371–1,600) of the excellent *Tool Engineers Handbook*, published in 1949. The sections include Cutting Tools, Punches and Dies, Jigs and Fixtures, Master Tooling and Limited Production Tooling. Each section is written by a specialist. Tables of data, bibliographies, charts, and drawings are included.

Basic Machine Operations. American Society of Tool Engineers, Book Committee; Frank W. Wilson, Editor-in-Chief. New York, McGraw-Hill Book Company, Inc., 1951. 235 pp., illus., diagrs. $2.75.

This is a reprint of Sections 28 through 42 (pp. 471–705) of the excellent *Tool Engineers Handbook*, published in 1949. The subjects covered are: milling; broaching; engine, turret, and single-spindle automatic lathes; single-spindle automatic and Swiss-type screw machines; multiple-spindle automatic bar and chucking machines; heavy horizontal and precision production boring; vertical boring mills and turret lathes; drilling, reaming, and counterboring; jig boring and grinding; planing; and shaping and slotting. Each section is written by a specialist. Bibliographies, tables of data, charts, and drawings are included.

Dynamic Motion and Time Study. James J. Gillespie. Brooklyn, N.Y., Chemical Publishing Company, Inc., 1951. 140 pp., illus. $3.75.

The author's point of view is that motion study involves the whole pattern of motion, the rhythm of the individual, and controllable factors that impinge on operator effectiveness. Micromotion study is seen as of no value in the dynamic situation. The author's teaching and practice are based upon the close relation of work activity to work psychology, and his aim is to describe techniques that are acceptable to both management and workman and which illustrate the practicability of motion simplification methods based on the whole motion pattern rather than on a motion pattern built up of bits of motion. The result is a challenging and most practical book.

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Modern Methods of Materials Handling. Materials Handling Institute, Inc. New York, Prentice-Hall, Inc., 1951. 248 pp., illus., diagrs. $5.50.

The greater part of this book (229 pages) describes about 150 specific cases of improved materials handling, illustrating uses of modern materials handling equipment in industry. A useful directory of about 60 manufacturers, listing their products, and a list of cooperating associations in the field are included.

REFERENCE WORKS

BIBLIOGRAPHIES

A Bibliography of Statistical Quality Control; Supplement. Grant I. Butterbaugh. Seattle, University of Washington Press, 1951. 141 pp. $2.00.

The original bibliography, published in 1946, included 712 papers, manuals, and books in English published from 1924 to 1946. This supplement lists about 725 items published from early 1946 to June, 1949. The indexes of authors and subjects cover both the supplement and the original bibliography. The field of statistical quality is interpreted broadly, and the bibliography covers statistical theory and practice, as well as numerous applications in the aircraft and other industries. Sampling, correlation, design of experiments, analysis of variance, theory of runs, frequency distributions, control charts, inspection, education in statistics, and measures of dispersion are among the subjects covered.

Bibliography of Supersonics or Ultrasonics, 1926 to 1949, with Supplement to 1950. Compiled by Beth Curry, Eugene Hsi, Jack S. Ambrose, Floyd W. Wilcox. Stillwater, Okla., Research Foundation, Oklahoma Agricultural and Mechanical College, 1951. 277 pp. $2.00.

Approximately 7,300 references, with annotations, are listed under about 84 subjects, including applications in various fields of applied mechanics, industry, research, physics, chemistry, and biology. About 675 of these were published in 1950. The indexes of authors include the complete references. The bibliography was compiled from twelve abstract services and indexes in various fields of science and engineering.

DIRECTORIES

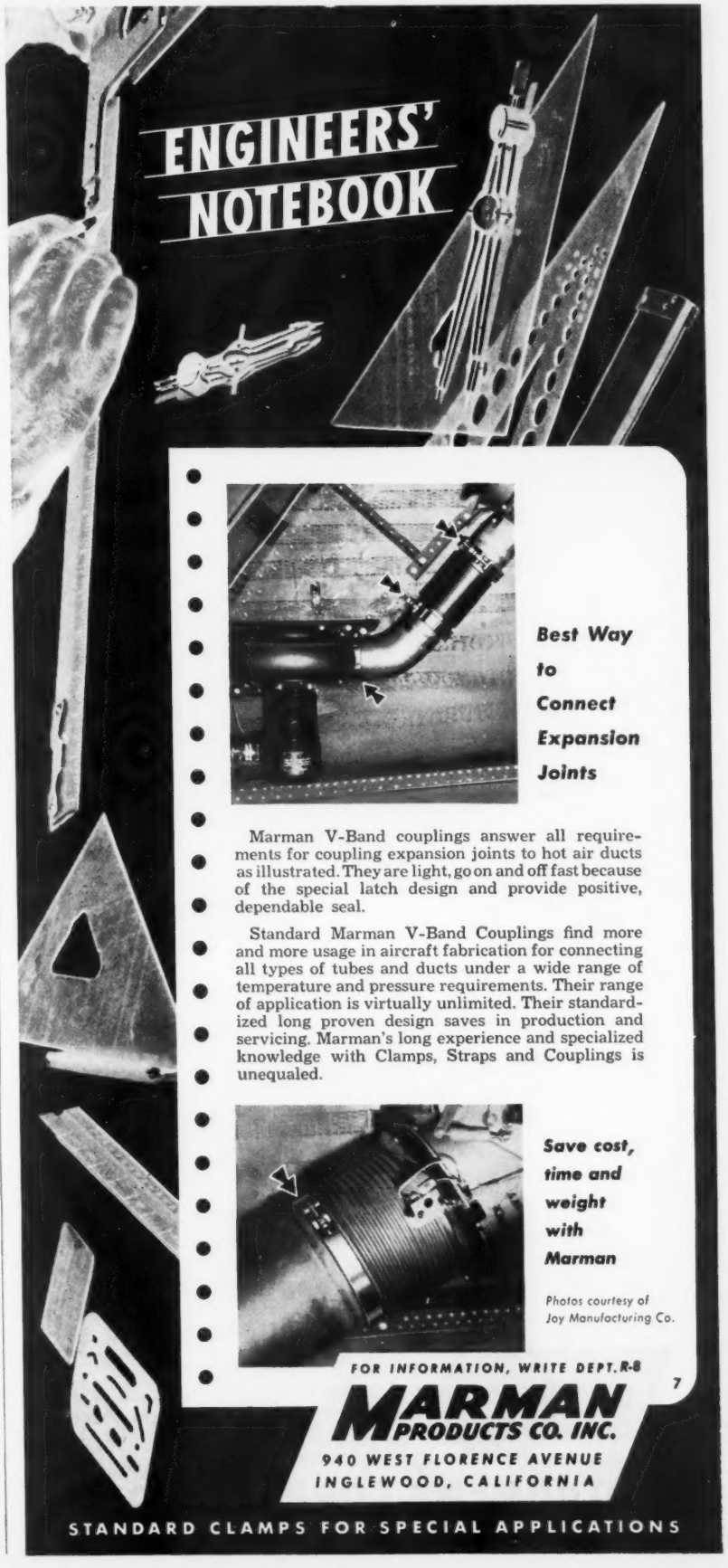
The Aeroplane Directory of British Aviation, Incorporating Who's Who in British Aviation. Edited by W. C. M. Whittle. London, Temple Press, Ltd., 1951. 689 pp. 15*s*.

The 1951 edition of this useful directory follows the lines of its predecessors, covering British Empire military and civil commands, departments, and ministries, aviation organizations, societies and clubs, including gliding clubs, airports, air lines, and manufacturers. This edition is larger by 105 pages. The greatest increase is in the section of allied manufacturers, including manufacturers of aircraft components and accessories, engine components, materials, tools and workshop equipment, airscrews, wheels, tires and brakes, instrument equipment, aircraft interior furnishing and equipment, parachutes, dinghies, clothing, fuels and oils, and air-base construction and equipment.

REPORT WRITING

Report Preparation, Including Correspondence and Technical Writing. 2nd Ed. Frank Kerekes and Robley Winfrey. Ames, Iowa, The Iowa State College Press, 1951. 448 pp. $6.90.

This textbook was first published in a photo-offset edition in 1948. The present edition is revised and printed by letter press. It covers the preparation of the technical report, including techniques in the collection of information, its assimilation and analysis, and the use of tables, charts, and other illustrative material. The mechanics of style and effective writing are considered, but the emphasis is upon the preparation of the first draft of the typewritten report, letter reports and short reports, formal reports, magazine articles and technical papers. There are separate chapters on correspondence, oral presen-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tation, editing, copyreading, and proofreading. Numerous illustrative specimens are included. The authors are respectively Assistant Dean of Engineering and Professor of Civil Engineering at The Iowa State College.

RESEARCH

Review of Current Research and Directory of Member Institutions. Engineering College Research Council of the American Society for Engineering Education. Cambridge 39, Mass., 77 Massachusetts Ave., Room 7-204, The Secretary, Engineering College Research Council, 1951. 244 pp. $2.25.

This edition features complete titles covering more than 5,200 engineering research projects that are now active in the 91 colleges and universities holding memberships in the Engineering College Research Council and that represent expenditures of over $50,500,000 per year. There is an alphabetical index to these projects of more than 4,000 entries. For each university, the book also contains the names of its responsible research administrative officers, a brief digest of policies governing research projects and contracts, the number of personnel engaged in research, annual expenditures, and special conferences and short courses of research interest. About 11,500 faculty members, graduate students, and research engineers are engaged in the research described.

Industrial Research Laboratories of the United States. 9th Ed. (National Research Council, Bulletin No. 120.) Washington, National Research Council, National Academy of Sciences, 1950. 443 pp. $5.00. A directory.

STRUCTURES

Strength of Materials. Max M. Frocht. New York, The Ronald Press Company, 1951. 439 pp., illus., diagrs. $5.50.

In this textbook, designed as a first course, the first three chapters deal with statically determinate problems in stress analysis, covering basic concepts and basic types of failure, tension, compression, bending, and torsion, and the place of statics in stress analysis. Basic Concepts of Strain and Axial Deformations, and The States of Stress and Strain at a Point are discussed in Chapters 4 and 5. The Significance of Static Stresses and Strains in Design is taken up in Chapter 6, in which photoelastic patterns are introduced. Shear and Bending Moments Stresses in Symmetrical Beams, Failure Under Steady and Alternating Stresses, and Torsion in Circular Shafts are next discussed, taking into account the requirements of the machine designer as well as of the structural engineer. The final chapters deal with Deflections of Beams, Statically Indeterminate Beams, Columns and Curved Beams, and Riveted Joints and Nonhomogeneous Beams. Answers to problems are included. This is a rewritten and rearranged outgrowth of the author's textbook of 1938, published jointly with the late Professor N. C. Riggs. Professor Frocht is Research Professor of Mechanics and Director of the Laboratory of Experimental Stress Analysis at the Illinois Institute of Technology.

Strength of Materials. Ferdinand L. Singer. New York, Harper & Brothers, 1951. 469 pp., diagrs. $5.00.

In this engineering textbook, the axial, torsional, and flexural basic types of loads are discussed separately; then various combinations of loads are discussed. The first eight chapters cover Simple Stress, Riveted and Welded Joints, Torsion, Shear and Moment in Beams, Stresses in Beams, Beam Deflections, Restrained Beams, and Continuous Beams. Combined Stresses, Reinforced Beams, and Columns are then taken up. Such special topics as repeated loading, stress concentration, theories of failure, impact loading, shear flow, shear center, unsymmetrical bending, curved beams, and thick-walled cylinders are discussed in a separate chapter. Moments of Inertia and useful tables are included in appendixes. Answers are given to the problems. The author is Associate Professor of Engineering Mechanics at New York University.

THERMODYNAMICS

Heat and Thermodynamics. J. K. Roberts. Revised by A. R. Miller. 4th Ed. London, Blackie & Son, Ltd., 1951. 593 pp., diagrs. 35*s*.

The last revision of this comprehensive textbook was published in 1940. New material has been added in accordance with new results appearing up to January, 1949, and in some cases as late as July, 1950. Material on low-temperature phenomena in particular has been expanded in the chapters on The Production and Measurement of Low Temperatures, Transformations of Higher Order, and The Third Law of Thermodynamics. This last chapter, called The Nernst Heat Theorem in previous editions, has been greatly expanded. The chapter on Theory of the Specific Heats of Solids was revised to take into account the lattice theory of specific heats. Indications of the phenomenologic approach to thermodynamics have been added throughout to supplement the classical discussion of the second law and the analytical methods of Gibbs. Mr. Miller is associated with The Royal Society Mond Laboratory of the Cavendish Laboratory at Cambridge University.

Engineering Thermodynamics. Herman J. Stoever. New York, John Wiley & Sons, Inc., 1951. 458 pp., diagrs. $5.75.

Designed for a one-year course, this textbook consists of three parts: The First Law of Thermodynamics, The Second Law of Thermodynamics, and Applications. The discussion is developed according to the thermodynamic principles involved, dealing, for example, with both perfect gases and actual fluids in connection with a given law. Graded problems are liberally included with answers for about half of them. The final section takes up applications to internal-combustion engines, refrigeration, compressors, nozzles and turbines various flow-measuring devices, air conditioning, and steam power plants, in separate chapters. The author is a Professor of Mechanical Engineering at The Iowa State College.

Basic Thermodynamics. Charles Leonard Brown. New York, McGraw-Hill Book Company, Inc., 1951. 266 pp., diagrs. $4.50.

Designed for a one-semester terminal course and requiring a knowledge of the elements of heat power, this textbook takes up fundamentals, the first and second laws of thermodynamics the properties of substances, reversible processes, and the perfect gas. Applications are discussed in separate chapters on Heating and Cooling Devices, Compressors, Pumps and Expanders, Vapor Power Cycles, Gas Power Cycles, Refrigeration, Nozzles, and Mixtures of Perfect Gases and Vapors. The final chapter discusses the elements of heat transmission. The author is an Assistant Professor of Mechanical Engineering at Purdue University.

SCIENCES, GENERAL

The Growth of Scientific Ideas. William P. D. Wightman. New Haven, Yale University Press, 1951. 495 pp., illus. $5.00.

This is the first American edition of a book published in Scotland in 1950. From the Ionians of the seventh century B.C., Professor Wightman traces and compares ideas of Matter and Motion in their settings and in their relation to past, future, and other fields of science. The first 24 chapters comprise this section. The final 9 chapters form a section entitled Nature and Life. Sources are listed for each chapter, and there is a brief general bibliography. A chronology and indexes of names and subjects are included. The author is the first incumbent of a new Lectureship in the History and Philosophy of Science at the University of Aberdeen and was formerly Head of the Science Department at Edinburgh Academy.

MATHEMATICS

Differential Equations. H. B. Phillips. 3rd Ed. New York, John Wiley & Sons, Inc., 1951. 149 pp., diagrs. $3.00.

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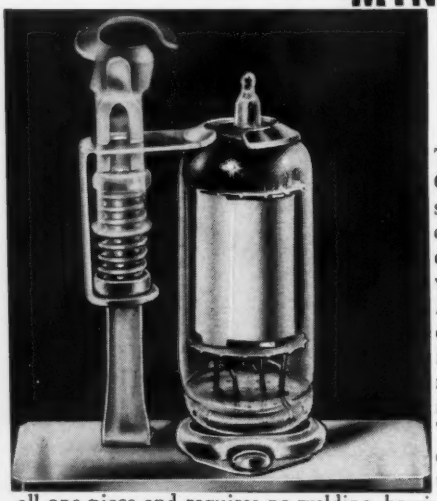

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This text was last revised in 1934. The present edition retains the original purpose—to provide a thorough drill in the setting up and integration of his own equations by the student and formal exercise in solving the usual types of ordinary differential equations. The sections on Variable Mass and on Linear Equations with Constant Coefficients have been rewritten. About 60 specific problems in geometry, science, and engineering have been added, and the book contains about 70 detailed illustrative examples. Answers are given to the problems. The author is Professor Emeritus of Mathematics and former Head of the Department of Mathematics at the Massachusetts Institute of Technology.

Partial Differential Equations of Mathematical Physics. Arthur Gordon Webster. Edited by Samuel J. Plimpton. 2nd Corrected Ed. New York, Hafner Publishing Co., Inc., 1950. 440 pp., diagrs. $8.00.

The first edition of this basic book was published in 1927, and the second was published in 1933; the present volume is a reprint of the 1933 edition. One of its features is the parallel discussion of the two alternative methods of solving differential equations, offering a unified treatment of methods associated with Cauchy's use of the Fourier integral (orthogonal functions) on the one hand and methods using normal functions (Green's method) on the other. The coverage of the "mathematical physics of the continuum" is thorough but is designed to show the underlying unity of method and of special methods as opposed to an assortment of mutually unrelated special devices.

Existence Theorems in Partial Differential Equations. Dorothy L. Bernstein. (Annals of Mathematics Studies, No. 23.) Princeton, N.J., Princeton University Press, 1950. 228 pp. $2.50.

This is a compilation of existence theorems that have been correctly proved and are applicable to numerical methods of calculation. In some cases, the applicability to electronic digital calculating machines is probable but not certain; however, the author clarifies the hypotheses under which solutions are established and defines the regions in which the solutions are valid. Lemmas are formulated connecting various problems, and transformations are indicated which permit the application of the solution of a given problem to solve related problems. The solutions have uses also in connection with problems of differential geometry and the calculus of variations. The work was done for the Office of Naval Research under contract with Engineering Research Associates, Inc. Professor Bernstein teaches at the University of Rochester.

Tables Relating to Mathieu Functions; Characteristic Values, Coefficients, and Joining Factors. (U.S. National Applied Mathematics Laboratories, The Computation Laboratory.) New York, Columbia University Press, 1951. 278 pp. $8.00.

These tables are more comprehensive than previously available tables and represent an important advance. The American notation is used, and conversion tables for the British notation are provided. The introduction by Gertrude Blanch furnishes an excellent introduction to the theory of Mathieu functions in their more practical aspects and explains the construction and use of the tables. Fields of engineering to which the tables apply include wave and diffusion problems connected with ellipses or elliptic cylinders, vibrations of elliptic membranes and plates, stability investigations of various mechanical systems, theory of frequency modulation, and electromagnetic waveguide theory.

Theory and Application of Infinite Series. Konrad Knopp. Translated from the Second German Edition and Revised in Accordance with the Fourth by Miss R. C. H. Young. London, Blackie & Son, Ltd., 1951. 563 pp. 35s.

This standard book was originally published in German in 1921, and new editions appeared in 1923, 1931, and 1947. The first English edition appeared in 1928 and was reprinted in 1944 and 1946. Following an introductory section on Real Numbers and Sequences, Foundations of the

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Theory of Infinite Series are discussed in six chapters, and the Development of the Theory is discussed in seven final chapters. Footnote references are included throughout, and there is a general bibliography of basic works. Professor Knopp teaches mathematics at the University of Tübingen.

Numerical Mathematical Analysis. James B. Scarborough. 2nd Ed. Baltimore, The Johns Hopkins Press, 1950. 511 pp., diagrs. $6.00.

The first edition of Professor Scarborough's standard work on approximate computation was published in 1930. The present edition is larger by 95 pages. The material on numerical integration and numerical solution of ordinary differential equations has been rewritten and expanded, including new material mainly on the accuracy of the solutions of systems of linear equations. A long chapter has been added on the numerical solution of partial differential equations, including the derivation of the equations of exterior ballistics and a shorter one on the numerical solution of integral equations. Much more attention is given to all the best methods of starting the solutions. The exercises have been revised and increased, and answers to most of them are given. The author is a Professor of Mathematics at the U.S. Naval Academy.

The Nomogram; the Theory and Practical Construction of Computation Charts. 4th Ed. H. J. Allcock and J. Reginald Jones. Revised by J. G. L. Michel. New York, Pitman Publishing Corporation, 1950. 238 pp., diagrs. $3.75.

This standard work was last revised in 1941. In this edition a final chapter has been added on the mathematical relationship between intersection and alignment nomographs on the basis of duality. This chapter discusses parallel-line coordinates as part of the theory. Practical principles, as in previous editions, are outlined. Cartesian coordinates are used throughout, the functional notation has been revised in accordance with accepted mathematical practice, and errors on the projective transformation of fourth-class nomograms have been corrected. Mr. Michel is with the Mathematics Division of the National Physical Laboratory.

Theory of Probability. M. E. Munroe. New York, McGraw-Hill Book Company, Inc., 1951. 213 pp., diagrs. $4.50.

This elementary textbook requires one year of calculus as a prerequisite. While important theorems that cannot be proved on this level are included, the necessary approximation of rigor in their treatment is pointed out. Stochastic variables are introduced early in the book, following the introduction of mathematical probability, and the discrete and continuous cases are handled side-by-side throughout, bringing the book somewhat beyond the status of a problem course in permutations and combinations. Answers are given to most problems. The author is Assistant Professor of Mathematics at the University of Illinois.

Mathematical Methods in Electrical Engineering. Myril B. Reed and Georgia B. Reed. New York, Harper & Brothers, 1951. 338 pp., diagrs. $5.00.

The authors' purpose is to present the essentials of mathematics which are likely to be useful to the electrical engineer. The manipulative aspects of the material are emphasized almost entirely, and fine points are omitted. Chapters cover Imaginary Numbers and Hyperbolic Functions; Linear Algebraic Equations-Determinants; Matrix Algebra, Zeros of Polynomials—Graeffe Method; Partial and Continued Fractions; Vector Analysis; The Fourier Series; Linear Differential Equations with Constant Coefficients; Transients in One-Mesh Electrical Networks; Transients in Multimesh Networks; Bessel Functions; Partial Differential Equations; Analytic Functions of a Complex Variable. Professor Reed has taught at the University of Texas, Illinois Institute of Technology, and at present is at the University of Illinois. Mrs. Reed was formerly Assistant Professor of Electrical Engineering at the Illinois Institute of Technology.

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The Main Stream of Mathematics. Edna E. Kramer. New York, Oxford University Press, 1951. 321 pp., illus., diagrs. $5.00.

In this book, designed for the layman, the role of mathematics in science and everyday life is explained with liberal use of historical and legendary material and practical examples. It is both a history and an exposition. The method of discussing arithmetic, algebra, geometry, trigonometry, statistics, calculus, and relativity by the use of familiar examples, and the historical development through the liberal use of anecdotes, keeps the book lively, and the shuttling between today and yesterday is pleasant. The author has taught in various universities in her native New York.

Practical Mathematics. Part III, Geometry with Applications. Claude Irwin Palmer and Samuel Fletcher Bibb. 5th Ed. New York, McGraw-Hill Book Company, Inc., 1950. 200 pp., diagrs. $2.20.

This standard volume, one of a series of four, was last revised in 1941. The present edition has been revised particularly in the illustrative examples, and new problems have been added. The senior author was late Professor of Mathematics and Dean of Students at the Armour Institute of Technology, and Associate Professor Bibb teaches mathematics at the Armour College of Engineering, Illinois Institute of Technology.

MECHANICS

Mechanics Applied to Vibrations and Balancing. D. Langharne Thornton. 2nd Ed. London, Chapman & Hall, Ltd., 1951. 584 pp., diagrs. 50*s*.

This book was first published in 1939. The present edition is larger by 55 pages and includes a new chapter on Dynamic Loading of Structures. Here particular reference is made to the transmission of stress under conditions of rapidly applied loading, as in the development of materials for certain forming operations and in the design of fortifications and ships to withstand the effects of explosions. The General Survey at the end has been rewritten and expanded. The first six chapters have been reproduced by the offset process with some amendments and additional references. They cover Balancing of Engines, Balancing of Locomotives, Theory of Vibrations, Propagation of Stress in Elastic Materials, Beams and Plates, and Rotating Shafts and Disks. Examples are taken from a wide range of engineering fields, including aeronautical, mechanical, and civil engineering and naval architecture. Footnote references are included throughout, and indexes of authors and subjects are supplied.

PHYSICS

Space—Time—Matter. Hermann Weyl. Translated by Henry L. Brose. New York, Dover Publications, Inc., 1951. 329 pp., diagrs. $3.95.

This is a reprint of the translation of the 4th edition of Professor Weyl's classic book, published in London in 1922. The author in his brief preface, dated 1950, discusses the unified field theory and the absorption of relativity theory after 1925 into quantum mechanics, referring to various papers and books that have been issued on these subjects between 1922 and 1950 and to a few changes in his own views. The main part of the book is reprinted without change.

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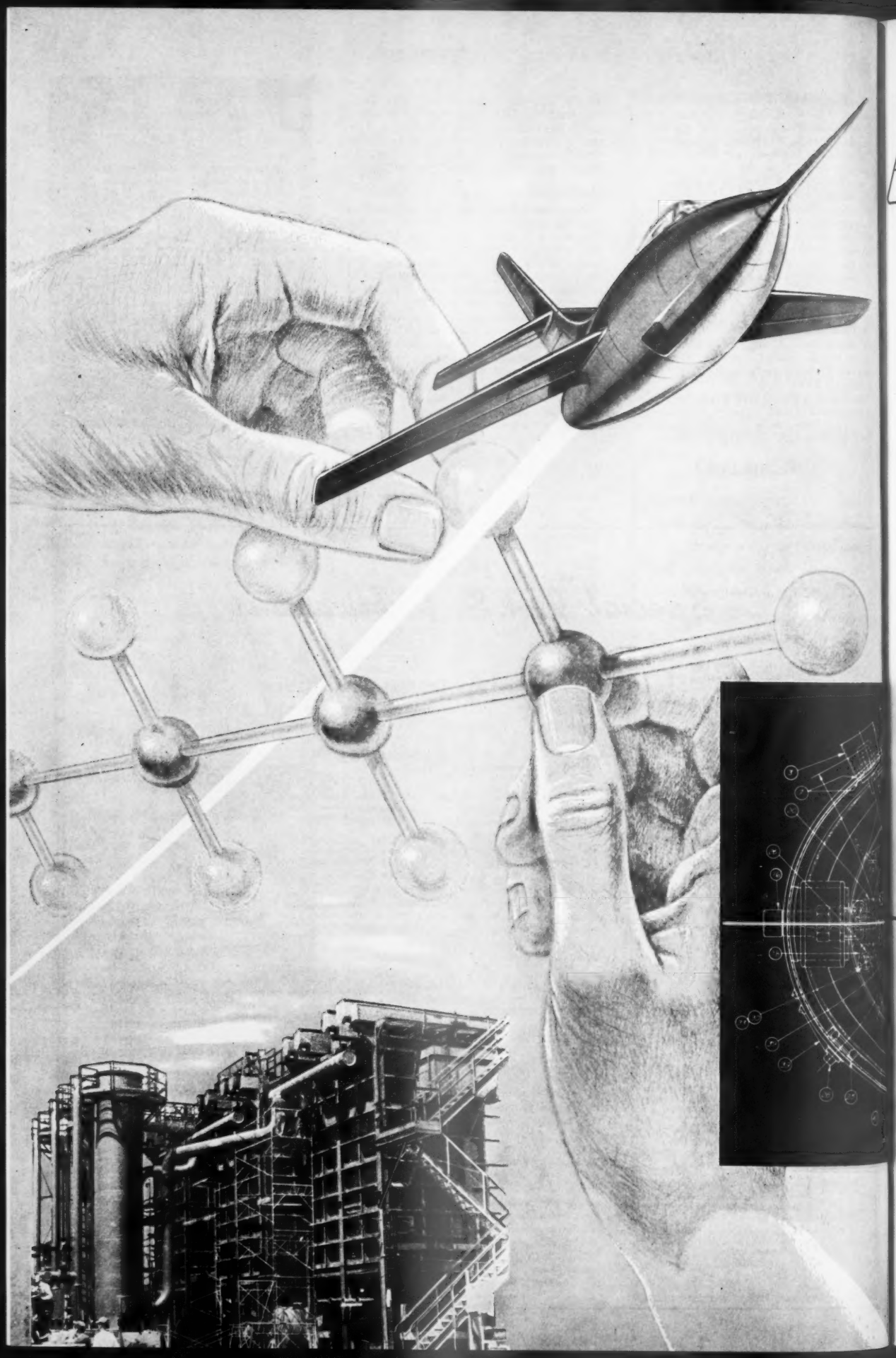

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Design Engineers—With two or three years' aircraft experience needed by small expanding company for essential military airplane projects. Must be familiar with layout procedure and able to supervise one or two men. Please submit full details, including education, experience, capabilities, availability, salary requirements, etc. Address: Engineering Department, Anderson, Greenwood & Company, Municipal Airport, Houston 17, Tex.

Structures Engineer—With two or three years' aircraft experience needed by small expanding company for essential military airplane projects. Must be familiar with loads, methods of analysis, and allowables. Please submit full details, including education, experience, capabilities, availability, salary requirements, etc. Address: Engineering Department, Anderson, Greenwood & Company, Municipal Airport, Houston 17, Tex.

Aircraft Development Control Engineer (Utility and Training)—Annual salary of $6,400. The position involves initiating rotary-wing aircraft design, promulgating design competitions, administering experimental and production contracts, and controlling changes and modifications to the aircraft. Make application to Employment and Employee Relations Unit, Bureau of Aeronautics, Department of the Navy, Washington 25, D.C.

Mechanical Engineers—Army Ordnance Design—Engineering ability to make original layouts and calculations required in the design of aircraft and ground-type rocket and missile launchers, aircraft and ground-type artillery and small arms weapons, and the mechanisms and control units involved, such as hydraulic and electrical power systems, structural elements, linkages, cams, gear trains, etc. GS-11, $5,400 per annum, bachelor degree plus three years' experience; GS-9, $4,600 per annum, degree plus two years' experience; GS-7, $3,825 per annum, degree plus one year experience; GS-5, $3,100 per annum, degree only. Lacking degree, combination of education and experience permitted. Applicants should submit Standard Form 57, application for Federal employment (available at any Post Office) to: Personnel Division, Rock Island Arsenal, Rock Island, Ill.

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319. Design Engineer-Pilot—B. Aero.E., 1939, plus graduate work at New York University and the University of Pennsylvania. Thirteen years of aircraft experience: one year in shop, eight years (1939–1947) in project and preliminary design and flight test on U.S. military aircraft, four years to date in design, flight test and teaching in foreign aeronautical institute. Commercial pilot since 1941, performing engineering flight tests since 1948. Presently Associate Professor and head of aircraft design department, with contract renewal offer. Prefers return to more active position utilizing and extending design and flight test experience.

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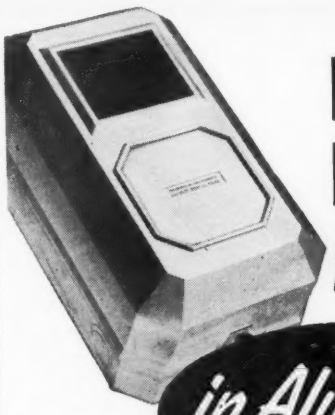

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In addition to its electronic and magnetostrictive characteristics, its electrical properties and its high transformation point, Nickel provides:

● **Toughness.** Nickel is one of the toughest of metallic materials as measured by the Izod or Charpy impact tests. One of its outstanding properties is its retention of impact strength and ductility at sub-zero temperatures.

Material	Condition	Impact Strength ft.-lb. Izod	Charpy U-Notch
Nickel	Hot-rolled	120+	197
	Cold-drawn	120+	195
	Annealed	120+	222

● **Endurance Limit.** Indicative of the amount of loading tolerable under cyclical changes of stress, these endurance limits were determined in a 10,000 rpm rotating-beam machine for polished specimens at room temperature.

Material	Condition	Endurance limit for 10 cycles psi	Tensile Strength psi	Endurance ratio
Nickel	Annealed	23,000 – 25,000	74,000 – 75,000	0.31 – 0.33
	As cold-drawn	38,000 – 45,000	98,000 – 126,000	0.36 – 0.40

● **Corrosion Resistance.** Nickel is a relatively noble element; in the physical chemists' electromotive series, it is shown to be 0.21 volts more noble than iron. As a general rule, oxidizing conditions favor corrosion of nickel while reducing conditions retard corrosion. Nickel is resistant to fresh and salt water, exhaust gases, and most organic acids and compounds.

● **Rigidity.** As measured by the modulus of elasticity in both tension and shear, the rigidity of nickel is practically the same as that of steel. Young's Modulus (in tension) is 30 million psi., and the modulus in shear is 11 million psi.

● **Shear Strength.** Shear tests in double shear on nickel bars showed 52,000 psi for annealed, 58,000 psi for half-hard, and 75,000 psi for full-hard.

● **Workability.** Nickel is easily worked by the common methods of fabrication: Machining, forging, spinning, drawing, bending and forming.

● **Welding, Brazing and Soldering.** Nickel can be joined by the usual welding, brazing and soldering processes common to industry.

● **Forms Produced.** Nickel is supplied in most commonly used mill forms—rods, flats, rounds, hexagons, sheet, plate, strip, bar, wire, and seamless tubes.

FOR FURTHER INFORMATION

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Minimum Mechanical Properties of Nickel

COLD-DRAWN WIRE (IN COIL)

Temper and Size Range	Tensile Strength 1000 psi	Yield Strength (0.2% offset) 1000 psi	Elongation in 2 in. per cent
Annealed	55	15	40
Regular Temper	105		4

COLD-DRAWN ROD AND BAR

Annealed			
Rounds, Squares, Flats Hexagons – all sizes	55	15	40
As Drawn			
Rounds, Squares, Flats Hexagons – all sizes	65	40	10

HOT-ROLLED ROD AND BAR

Rounds, Squares, Flats, Hexagons – all sizes	60	15	40

FORGED ROD AND BAR

Form and Size Range	Tensile Strength 1000 psi	Yield Strength (0.2% offset) 1000 psi	Elongation in 2 in. per cent
Hot finished	65	20	40
Annealed	55	15	40

PLATE, SHEET AND STRIP

Hot-Rolled Plate			
Annealed	55	15	40
As-Rolled	55	20	35
Cold-Rolled Sheet			
Annealed	55	15	40
Cold-Rolled Strip			
Annealed	55	15	40
Spring	90	70	2

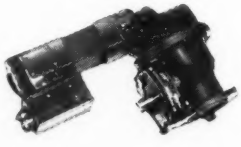
SEAMLESS PIPE AND TUBING

Cold Drawn			
Annealed	55	15	40
Hard Stress-Relieved	65	40	15
Stress Equalized	70	50	10

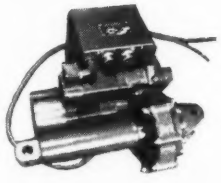
EEMCO technical bulletin

MOTOR ACTUATORS FOR AUTOMATIC FLIGHT

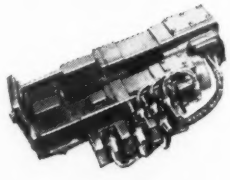
Today's aircraft fly on the edge of human capabilities and endurance. A transition from conventional piloted aircraft to pilotless types is taking place. The development of foolproof power units to actuate controls is a primary factor in the achievement of automatic flight. These units are being designed and produced by EEMCO in close cooperation with the builders of tomorrow's aircraft.



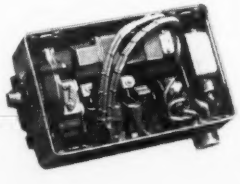
Rotary Actuator for Rugged Duty This Rotary Actuator was designed for trim tab actuation in a long range bomber involving the most rugged duty cycle. It operates almost continuously with the automatic pilot. Required duty cycle is one second full load, one second off and one second full load in opposite direction, continuous. Silicone insulated and high temperature materials used throughout.



Stabilizer Actuator for Large Jet Fighters This unit incorporates two motors of different size, driving into individual gear reductions to operate the screw jack. Small motor of 1/10 h. p. output operates almost continuously with automatic pilot. The large intermittent duty 3.3 h. p. motor provides manual operation of screw jack by pilot for maneuvering.



Double Motor Power Unit This unconventional system operates the horizontal stabilizer on a turbo prop aircraft of recent design. A small continuous duty motor of 1/15th h. p. operates through a gear reduction in conjunction with automatic pilot. Large intermittent duty 3½ h. p. motor with direct drive of 12,000 rpm is used for manual operation.



Rotary Actuator Package This system provides manual or automatic pilot elevator operation on one of the latest jet fighters. Totally enclosed in box equipped with mounting bracket it incorporates motor, magnetic clutch, radio noise filter and brake. Gear reduction, and auxiliary gear reduction operate adjustable travel limit switches and position indicator. Output rpm at 3 inch – pounds loads, 2500. Weight, complete, 3¼ pounds.

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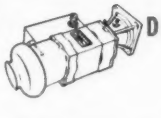
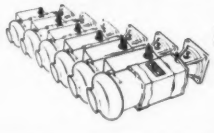


DEVELOPMENT



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